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Place	Date	Nature	Manuscript Closing Date
New York, N. Y.	Jan. 23-27, 1933	Winter Convention	(Closed)
Schenectady, N. Y.	May 10-12, 1933	District Meeting	Feb. 10, 1933
Chicago, Ill.	June 26-30, 1933	Summer Convention	March 26, 1933
Salt Lake City, Utah	Aug.-Sept. 1933	Pacific Coast Convention	May-June 1933

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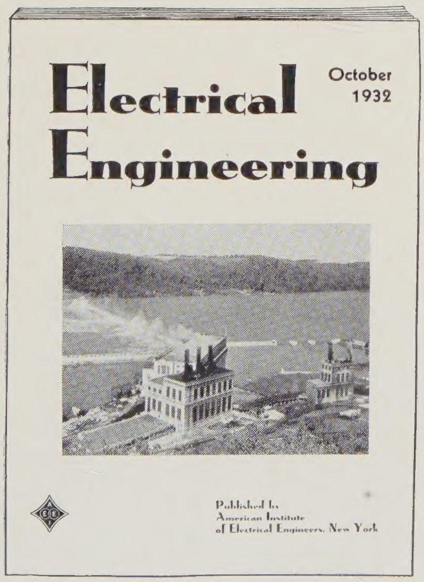

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This Month—

Front Cover

An electric passenger train leaving the west end of the famous Cascade tunnel on the Great Northern Railway in Washington. The tunnel is 7.79 miles long and cost $14,000,000 to build; it was completed early in 1929. The locomotive is of the single-phase motor-generator type operating on 11,000 volts, and weighs 260 tons.

—Turn to Next Page

PULP insulation may now be applied directly to the conductor of a telephone cable, the paper making and insulating operations being combined into one process. A considerable saving over spirally wrapped paper insulation is made possible by the use of a low cost Kraft pulp and the elimination of the paper making, paper splitting, and handling operations. *p. 838–43*

DISCUSSIONS of the technical papers presented at the Institute's Middle Eastern District meeting, Baltimore, Md., October 10–13, 1932, have been reviewed and summarized. *p. 877–9*

UNLIMITED range is available in a new electrostatic voltmeter for measuring either a-c or d-c potentials. It is a rugged and portable instrument, has high accuracy, short period, linear scale characteristics, and draws no current. *p. 863–5*

LIGHTNING protection has been carefully considered in the design of the Safe Harbor-Westport 230-kv transmission line. Insulation is particularly heavy, ground wire protection has been applied according to the latest theory, and special effort has been made to reduce tower to ground resistances. *p. 834–8*

SYNCHRONOUS motors applied to constant speed main-rolls in metal rolling mills, both steel and non-ferrous, are rapidly increasing in favor, due to improvements in the synchronous motor and its control, and the favorable first cost. *p. 855–8*

FAULT location on power cables has been facilitated by one company through the use of constant current transformer for reducing high initial fault resistance, and a short circuiting switch for generating signals which locate the fault. *p. 870–2*

QUICK stopping of synchronous machines usually can be accomplished most satisfactorily by dynamic braking. Accurate prediction of the number of revolutions and time required to stop now can be made by means of simple formulas. Changes in excitation during the stopping period are taken into account. *p. 843–5*

ECONOMIC aspects of water power have been analyzed to facilitate comparison between hydroelectric and steam plants. The capacity and energy costs of hydroelectric power are expressed in terms of the cost of steam power, and various factors affecting any decision as to whether a hydroelectric or steam power plant is to be built are discussed. *p. 849–52*

METAL transfer during electric arc welding, although subjected to much discussion, is not fully understood. The mechanism of this transfer has been studied by a new method which it is stated records all of the possible forms of metal transfer, by means of a metallic strip moving at high speed through the arc. This method indicates that liquid globules are the chief form of metal transfer. *p. 852–4*

CHANGES have been made in the prizes which the Institute presents for technical papers. These changes concern the prizes for national, Section, and Branch papers. Although the cash awards have in some cases been eliminated, ample incentive for the preparation of well written papers should remain. *p. 875*

TECHNICAL papers to be presented at the 13 sessions of the Institute's coming winter convention to be held in New York, N. Y., January 23–27, 1933, have been tentatively arranged. The subject balance of these papers is particularly good, and should draw many to attend the convention. *p. 873–4*

ACTIVITIES in unemployment relief during the winter 1931–32 were summarized in ELECTRICAL ENGINEERING for November 1932, p. 809–13. Supplementing this article, suggestions which have been received from many Sections of the Institute, giving methods which may be followed during the coming winter, are presented in the present issue. *p. 880–2*

HOUSE telephone cables for large buildings require consideration of many factors to insure that the telephone plant shall be used with the maximum degree of efficiency. *p. 867–9*

Recommended Practises for the Protection of Electrical Apparatus

The relay subcommittee of the A.I.E.E. protective devices committee herewith submits its recommendations for the protection of electrical apparatus. These recommendations are based upon a questionnaire and the 37 replies thereto from specialists in this field. Answers were interpreted and codified by a group of 20 experienced engineers particularly interested in the protection of electrical apparatus and circuits. It is hoped that this concensus of present-day opinion will be the beginning of a series that will be augmented and improved with each periodic analysis and reissue.

IN THE PAST, 3 papers entitled "Transmission Line Relay Protection" have been presented before the Institute. These indicated the progress of the protection art and discussed in some detail certain methods considered general practise at the time they were written. The last one, presented in 1930, contained brief notes on the protection of some of the major items of system equipment. At that time, however, it was believed desirable to have a similar paper prepared, which would be devoted to apparatus protection. It is therefore the purpose of this report to present a review of those methods that are in general favor at the present time, and that are considered good practise for the protection of the main items of electrical apparatus.

Information upon which this report is based was furnished by representative engineers associated with protective problems in public utility and industrial fields. In order that the survey might be as comprehensive as possible, 61 copies of a questionnaire were distributed, of which 35 were returned. To guard against answers being given in the light of past practise the transmittal letter emphasized particularly the value of opinions based upon future applications rather than upon existing installations. Therefore it may be assumed confidently that the condensed results given express the most advanced ideas of a preponderant body of engineers engaged directly in the study of protection problems.

In but few cases the average opinion expressed in the questionnaires differs from the views of the committee. Where such disagreements occur, both opinions are given, together with the reasons that influenced the committee in qualifying the average opinion disclosed by the questionnaire. While agreement was not always unanimous, no radically different views were found to exist.

There appears to be a growing recognition of the importance of considering protection problems from 2 major viewpoints: (1) their monetary significance as insurance against damage to equipment; and (2) the less tangible, but no less vital relation they bear to the value of the service in terms of good-will. The former may be computed readily from existing records of repair costs; the latter is more difficult to evaluate in a pecuniary sense and consequently is susceptible to a variety of conclusions when considered from the angle of return on capital invested. It is not disputed that this return is large, especially in comparison with the cost of the protective devices, and that it probably will loom still larger as power system growth and interconnections continue.

In arriving at the opinions expressed the committee duly weighed the cost of the protective equipment against the value of the results to be expected. This procedure will be found borne out by the kilovolt-ampere ratings for which the more expensive methods of protection are recommended. Not only is a large piece of apparatus inherently more costly than a small one, but its incapacity to operate will result in relatively greater inconvenience to the system it serves.

It should be remembered also that these recommended ratings apply to the general case and that special situations will arise in which it may be

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Full text of a report (**A.I.E.E. Paper No. 33-1**) prepared by the relay subcommittee of the protective devices committee to be presented at the A.I.E.E. winter convention, New York, N. Y., Jan. 23–27, 1933.

Members of relay subcommittee—O. C. Traver, *chairman*, Genl. Elec. Co., Phila., Pa.; E. H. Bancker, Genl. Elec. Co., Schenectady, N. Y.; D. L. Bement, Northern Ind. Pub. Serv. Co., Hammond, Ind.; H. D. Braley, N. Y. Edison Co., New York, N. Y.; R. E. Cordray, Genl. Elec. Co., Phila., Pa.; G. B. Dodds, Duquesne Lt. Co., Pittsburgh, Pa.; W. W. Edson, Edison Elec. Illum. Co., Boston, Mass.; L. E. Frost, Bklyn. Edison Co., Bklyn., N. Y.; E. E. George, Tenn. Elec. Pwr. Co., Chattanooga, Tenn.; S. L. Goldsborough, Westinghouse E. & M. Co., Newark, N. J.; W. A. Lewis, Westinghouse E. & M. Co., Pittsburgh, Pa.; H. A. McLaughlin, Central Hudson Gas & Elec. Co., Poughkeepsie, N. Y.; J. H. Neher, Phila. Elec. Co., Phila., Pa.; R. E. Pierce, Elec. Bond & Share Co., New York, N. Y.; C. F. Powers, New England Pwr. Corp., Boston, Mass.; H. M. Rankin, Metropolitan Edison Co., Reading, Pa.; A. W. Rauth, Consumers Pwr. Co., Jackson, Mich.; F. O. Schnure, Bethlehem Steel Co., Sparrows Point, Md.; H. P. Sleeper, Pub. Serv. Elec. & Gas Co., Newark, N. J.; E. R. Stauffacher, So. Calif. Edison Co., Los Angeles, Calif.; George Steeb, Buffalo Niagara & Eastern Pwr. Corp., Buffalo, N. Y.; and E. M. Wood, Hydro Elec. Pwr. Comm., Toronto, Canada.

Others who supplied data through their replies to the questionnaire—T. J. Bostwick, Aluminum Corp. of America, Pittsburgh, Pa.; E. A. Childerhose, Stone & Webster Co., Boston, Mass.; H. W. Collins, Detroit Edison Co., Detroit, Mich.; L. E. Cook, Texas Pwr. & Lt. Co., Dallas, Tex.; A. C. Cummins, Carnegie Steel Co., Duquesne, Pa.; C. H. Frier, Okla. Gas Co., Okla. City, Okla.; G. W. Gerrell, Union Elec. Lt. & Pwr. Co. St. Louis, Mo.; A. S. Goodrich, Hammermill Paper Co., Erie, Pa.; H. H. Green, Pa. Pwr. & Lt. Co., Hazleton, Pa.; J. Hellenthal, Puget Sound Pwr. & Lt. Co., Seattle, Wash.; A. V. Joslin, Pacific Gas & Elec. Co., San Francisco, Calif.; J. T. Logan, Georgia Pwr. Co., Atlanta, Ga.; C. A. Muller, American Gas & Elec. Co., New York, N. Y.; P. H. Robinson, Houston Ltg. Co., Houston, Tex.; J. J. Samson, Commonwealth Edison Co., Chicago, Ill.; C. J. Smith, Illinois Steel Co., Chicago, Ill.; and E. B. Wagner, Lehigh Valley Coal Co., Wilkes-Barre, Pa.

deemed advisable either to raise or to lower them. Machines of a certain rating may seem small on a large system and yet attain considerable importance when the system to which they are attached is itself small. In view of the difficulty of basing recommended ratings upon the size of the system the committee felt that it was preferable to consider such ratings upon the more definite basis of intrinsic values and relative costs of protection.

This report deals particularly with protection against electrical and mechanical failure. When applied to unattended apparatus it overlaps to some extent the field of A.I.E.E. STANDARDS NO. 26 on automatic stations which embrace protection against control failure.

A-C GENERATORS

Differential Protection. In general differential protection is recommended for a-c generators. Equipment used for this protection should disconnect the line and field simultaneously and also the neutral if an adequate circuit breaker is provided. In some cases it shuts down the prime mover. This equipment also should prevent any dangerous rise of exciter voltage when the exciter is connected directly to a hydroelectric generator, or in any other situation in which the exciter may attain excessive speed upon loss of load on the prime mover. As a further precaution against the spread of destructive effects following an internal failure, the differential relay may be utilized to liberate carbon dioxide within the shell of any machine that has a degree of enclosure sufficient to render the gas effective.

For generators of either the open or enclosed type at attended stations differential protection is recommended for ratings of 1,000 kva and higher. The average, as derived from answers to the questionnaire, is 3,000 kva; but in view of the intrinsic value and the good results on record the committee felt justified in lowering this figure. At unattended stations differential protection is recommended for generators rated at 250 kva and higher.

From the standpoint of service, frequently a small generator may be as important as a larger one; this is especially true where a small machine is operating directly on a bus with larger generators which already are provided with differential protection. In such case a fault in the small generator, if not quickly removed, may prove as embarrassing to the service as a similar fault in a large generator; hence here differential protection for the small machine is strongly indicated.

In view of the decreased hazard of insulation failure at low voltages this form of protection is recommended only on machines rated at 2,300 volts and higher. This opinion is strengthened by the high currents usually encountered at lower voltages, since these require rather massive terminals and involve greater difficulty in bringing out all of the necessary armature leads.

It is recommended that the zone protected by the differential relay include as far as possible all conductors that extend from the generator armature to the bus and the circuit breaker as well.

On generators of 20,000 kva or larger, having 2 or more parallel windings per phase and where there is a possibility of turn-to-turn failure, it is recommended that additional protection be provided in the form of a differential relay actuated by a difference of in-phase currents that may occur in the parallel windings. When the neutral is solidly grounded a turn-to-turn fault will develop quickly into a fault to ground; therefore this protection is recommended particularly in cases where the generator neutral is not solidly grounded. The possibility of circulating currents also must be investigated when parallel balance is contemplated; perhaps, however, these can be avoided when the machine is designed. Unless this precaution is taken it is possible that on external faults circulating currents may cause improper operation of the relay. With some types of armature windings this relay also is capable of detecting short-circuited turns in the field winding. Since this form of protection is recommended only for large machines its provision adds but a small fraction to the over-all cost of the unit.

Overcurrent Protection. The use of overcurrent protection for generators in attended stations is not regarded favorably, but is recommended for back-up protection at unattended stations. When generators at attended or unattended stations are not provided with differential protection, then overcurrent devices, actuated either directly by the armature current or by its thermal effect as in a replica relay, should be employed. However, because of the rapid decrement of the short-circuit current, care must be exercised in the use of overcurrent relays.

A replica relay operates at a specific temperature of its own mechanism which is designed to have at all times the same temperature as the device protected, when subjected to the same ambient conditions. Other types of temperature relays function on the actual temperature of the machine as determined by elements in direct contact, such as embedded temperature coils or thermocouples. Temperature relays are regarded as a valuable guide to the operator. It is the general opinion that in attended stations they should not disconnect the machine, but should provide only a warning signal.

Field Temperature Protection. In general field temperature protection is not recommended. An exception, however, is made in favor of its application to generators that are provided with high speed excitation and paralleled over long transmission lines. Under short-circuit conditions a heavy field is applied quickly to hold these generators in step; if this field current is not reduced within a reasonable time it is possible for the generator field to overheat without the knowledge of the operator. To guard against this contingency a field temperature relay may be provided to sound an alarm in attended stations and to shut down the overheated machine if the station is unattended.

Power-Directional Protection With Time Delay. In the past this combination of protective devices occasionally has been used to prevent motoring on the part of a steam-turbine-driven generator. Since the purpose which it served now can be taken care

of automatically at the throttle, it is the general opinion that, except perhaps in rare cases, the need for this form of protection no longer exists. Its use as a protective measure against internal insulation failure is not recommended and can be justified only in the case of old machines which are not provided with sufficient armature terminals for the application of differential protection.

Bearings. Temperature protection is recommended for the main bearings of all unattended machines.

Protection Against Overspeed. It is agreed that the usual provision at the prime mover for protection against overspeed is satisfactory for the purpose and that nothing further should be necessary.

Protection Against Accidental Loss of Field. Protection against loss of field is recommended for disconnection of the generator at unattended stations. A d-c undercurrent relay is the logical device for this purpose, but it must be given a suitable time delay to prevent its operation during transients reflected from the armature under short-circuit conditions. In attended stations this type of protection seldom is used; where it is used the relay should not disconnect the generator but may provide an indication to the operator upon the occurrence of this condition.

Frequency Converters; Synchronous Condensers

Recommendations regarding protective equipment for a-c generators apply also to frequency converters and synchronous condensers. In addition it is believed that some provision (usually time overcurrent relays) should be made for disconnecting a frequency converter under out-of-step conditions. Usually it is advisable to provide also time-delayed undervoltage protection for synchronous condensers. No distinction is made between attended and unattended stations in the use of these additional features.

D-C Generators

At attended stations protection against overcurrent is considered necessary for d-c generators and, in addition, when these machines operate in parallel with another source of power, provision should be made for protection against reversal of the normal direction of current flow, functioning independently. Additional refinements are usually necessary in unattended stations, but the variety and special nature of these devices do not permit of their inclusion in a general condensed report. They may be found listed in A.I.E.E. Standards No. 26.

Bearings. Temperature protection is recommended for the main bearings of all unattended machines.

Exciters. When exciters are direct-connected and do not operate in parallel, it is recommended that no protection against electrical failure be used. For parallel operation, protection against overcurrent in a reverse direction should be provided. The current setting should be high enough to prevent possible disconnection of the machines when paralleling and when momentary disturbances are reflected from the a-c generator armature during a-c short circuits.

Power Transformers and Power Auto-Transformers

Differential Percentage. When circuit breakers are provided for each winding, percentage differential protection is recommended for 2- or 3-winding power transformers of 1,000-kva rating and higher, either with or without tap-changing equipment, and whether operated singly or in parallel. As disclosed by the questionnaire the average minimum rating for which differential protection is recommended was found to be 5,000 kva. The committee recommends that differential protection always be provided for banks of 5,000 kva and more if operated in parallel, even though additional breakers must be purchased. When the transformer bank is part of a line and is provided with a circuit breaker on the bus side only, certain modifications of the foregoing method are recommended. These will be found under a subsequent heading.

When the necessary circuit breakers are provided for complete isolation of a power auto-transformer, percentage differential protection is recommended for an equivalent physical capacity of 1,000 kva and greater. It is recommended also that all banks of power auto-transformers operated in parallel of an equivalent physical capacity of 5,000 kva and greater be provided with differential protection even though additional breakers must be purchased. The auto-transformer output rating corresponding to 1,000 or 5,000 kva of equivalent physical capacity will vary, of course, with the ratio of voltage transformation. In general the ratio of the equivalent physical capacity of an auto-transformer to its output is equal to the per cent voltage transformation, based upon the high voltage thus:

$$\frac{\text{Equivalent capacity}}{\text{Rated output}} = \frac{E_1 - E_2}{E_1} = 1 - \frac{E_2}{E_1}$$

where E_1 is the high voltage, and E_2 the low voltage.

It is recommended that circuits embraced by the differential protection include all conductors up to and including the circuit breakers on each side of the transformer.

Overcurrent Percentage (Differentially-Connected). When differentially-connected overcurrent relays are used in place of percentage differential protection for any of the foregoing types of transformers, it is recommended that they be of the inverse time type. This time characteristic prevents operation on external faults which otherwise may create sufficient unbalance at the relay to bring about needless tripping.

Back-Up Protection. In addition to differential protection, overcurrent or other back-up protection (not necessarily at the transformer itself) should be provided at some point on the source side to protect the transformer against the effects of sustained excess currents which may arise from failure of protective apparatus to clear faulty equipment. Temperature relays, either operated by embedded coils or of the replica type (described under "A-C Generator Over-Current Protection"), also occasionally are employed. When a transformer is not protected by differential methods it is recommended that overcurrent protection always be provided.

Smoke or Gas Detectors. Insufficient experience with these devices in the United States precludes the expression of an opinion regarding their value, or their possibilities, as a means of transformer protection.

Transformers Having Breakers Only in the Low Side. Power transformers that have a circuit breaker on the bus side only, the other side being connected directly to the line, generally are treated as part of the line and consequently included in the line protection. When the latter is protected by distance or directional overcurrent relays it is suggested that differential protection also be considered for the power transformer and that this protection be arranged to trip the transformer breaker. Under some circumstances this will result in speedier isolation of the disturbance. For example, if a fault occurs in the transformer during a period when normal power is flowing from the bus toward the far end of the line, the directional relay at the distant end cannot respond to the fault current until it has grown to proportions sufficient to overcome the torque produced by the normal direction of power. By quickly tripping the bus breaker, however, the differential relay interrupts the normal flow of power and thus frees the distant directional relay of its normal power torque. The directional relay then responds to the feeble fault current and the transformer is isolated before serious damage can result.

Magnetizing Transients. Replies to the questionnaire disclose that trouble from magnetizing transients is of sufficiently frequent occurrence to warrant some statement by the committee regarding means for overcoming its effect on the protective relays. Inrush magnetizing currents disturb the balance at the differential relay, and may cause needless tripping of the breakers. The ability of power sources of large capacity to maintain full voltage at the inception of the transient adds greatly to the magnitude which it may attain. These abnormal currents are caused primarily by the residual magnetic flux; should this be of appreciable magnitude, and in a direction such that the flux change required by the voltage at the moment of switch closure will push the total flux above the knee of the saturation curve, it follows that the magnetizing current will be unduly large. The difficulty is more pronounced on 25-cycle systems.

Special or additional equipment is available for preventing tripping during the magnetizing transient and this precaution is always necessary when high speed relays are used. The more common types of relays, however, being slower, usually will ride safely through the transient; where such relays are employed the committee believes that the addition of the special equipment referred to should be based more properly upon the trouble which the user encounters.

It is pointed out also that undesired operation of differential relays may occur at the moment of clearing an external fault originating in the vicinity of the transformer. Just before the fault is cleared the voltage at the transformer may have fallen to 0 and immediately afterward will tend to return to normal, thus simulating on a smaller scale the conditions obtaining at initial magnetization. Experience with trouble arising from this cause having been meager, the committee does not feel called upon to suggest measures for its avoidance.

A-C Motors

An analysis of the replies to the questionnaire indicates a general agreement on the desirability of differential protection for large a-c motors, the average minimum rating at which it should be applied being 1,750 hp. It was the opinion of the committee that motors of 2,000 hp and more, with a minimum rating of 2,200 volts, should be provided with differential protection.

Overcurrent Protection. In addition to differential protection, temperature relays, either of the replica type or operated by embedded coils, are recommended for protection against excessive or prolonged overloads. Due to loss of cooling by windage the latter will represent more accurately the true motor temperature under stalled-rotor conditions.

For motors of less than 2,000-hp rating where differential protection is not employed inverse time overcurrent and instantaneous overcurrent protection is recommended, the instantaneous relay being set for currents greater than the stalled-rotor current to take care of severe short circuits only.

Undervoltage Protection. When undervoltage protection is used it should have sufficient *time delay* to enable the motor to coast through temporary dips in voltage. Undervoltage protection is not recommended for motors that start on full voltage since these will come up to speed automatically when normal voltage is resumed.

Phase-Rotation Protection. Relays to guard against reversal of phase-rotation are recommended chiefly for use at unattended stations and in elevator service.

Protection Against Unbalanced Phase Currents. Dielectric failure results in unbalanced phase currents and negative phase-sequence components. This condition may be detected by a relay which is actuated either by the unbalanced phase currents themselves or by their corresponding negative phase-sequence components. When differential protection is not possible or practicable these relays frequently are used at unattended stations; but it should be remembered that phase-balancing action will produce unbalanced conditions in sound motors and thus may lead to erroneous tripping of circuit breakers on the occasion of an external unbalanced fault.

Bearings. Temperature protection is recommended for the main bearings of all unattended machines.

Power Station Essential Auxiliary Motors. It is important that motors driving essential power station auxiliaries not be removed from service except as a last resort and then, in the interest of service, their isolation should be accomplished as promptly as possible. For this reason it is recommended that such motors be protected by instantaneous overcurrent relays set for currents considerably greater

than the stalled-rotor current. When temperature relays are used in connection with these motors they should be arranged to sound an alarm only. Phase-balance relays or negative phase-sequence relays are not recommended for essential motors because of the phase-balancing tendency of polyphase motors mentioned in the second preceding paragraph.

It is not common practise to ground the neutral of the supply source for essential motors, but if for any reason such a condition exists, ground relays advantageously may be added to the protection.

D-C Motors

Fuses are considered sufficient protection for small d-c motors. For medium and large sizes overcurrent and undervoltage protection, usually self-contained in the air circuit breaker itself, are recommended. Where the machine is very large, and its service correspondingly important, additional refinement in the form of temperature protection is desirable.

Bearings. Temperature protection is recommended for the main bearings of all unattended machines.

Synchronous Converters

Synchronous converters require protection on both the a-c and the d-c sides. On the a-c side inverse-time overcurrent protection is recommended to trip the oil circuit breaker. In addition, when the d-c side is grounded and flashover possible, an instantaneous flashover relay, connected between the machine frame and ground, is recommended to disconnect both the a-c and d-c sides. If the possibility of flashover exists, and no flashover relay is provided, it is recommended that the overcurrent protection on the a-c side be instantaneous instead of inverse time. For the d-c side instantaneous overcurrent protection is recommended, and in addition, when the machines are operated in parallel, separate reverse current protection should be provided to disconnect the converter when power flows toward it from the d-c bus. Most synchronous converters are equipped with mechanical overspeed devices; these should trip the d-c circuit breaker and, if the system is subject to runaway speeds, the a-c circuit breaker also. Additional information will be found listed in the A.I.E.E. Standards No. 26 on Automatic Stations.

Bearings. Temperature protection is recommended for the main bearings of all unattended machines.

Rectifiers

Rectifiers are almost universally automatic in their operation. It is believed that recommendations for their protection are covered adequately by the tabulation given in A.I.E.E. Standards No. 26 on automatic stations.

Bus Protection

Differential. All failures occurring on important buses should be promptly isolated. Differential methods which balance all currents entering and leaving the bus are recommended for this purpose. In such applications it is important that the ratio characteristics of the current transformers in the differential circuit should hold substantially within the relay setting at the maximum primary currents so that incorrect operation cannot occur on external faults. With a given core design the higher the transformation ratio the more accurate is the ratio curve. Desired conditions can be achieved best by the use of a single ratio for all current transformers taking part in the differential scheme. If it is not possible to follow this recommendation and current transformers of different ratios are employed, then auxiliary current transformers must be used in the secondary circuits to equalize the different ratios at the balance point.

It should be noted, however, that when an auxiliary transformer is used to increase the ratio of a low-ratio line current transformer, a double handicap is placed upon the equipment compared to that which would result from the use of a single current transformer having the same total ratio. This follows because: (1) In the lower-ratio transformer ratio-error begins at lower currents; and (2) the additional burden imposed by the auxiliary transformer also has the effect of increasing the ratio-error in the line current transformer.

Under certain conditions of power feed restraint may be used advantageously in the differential relay. In general, however, these conditions do not obtain and the effect of restraint if used cannot be predicted with any degree of certainty.

Ground Fault Bus. When the system is grounded a ground fault bus may be used, each protective relay being operated by a current transformer inserted in the common ground connection for its particular bus section. If provision be made for the application of this method during the station design period, its installation does not involve the serious constructional difficulties that may be encountered in attempting to introduce it in an existing station.

Grounding Equipment

Grounding Resistors and Reactors. It is recommended that grounding resistors and reactors be protected by overcurrent or temperature relays which, after a short delay sufficient to allow line protection to function, will initiate an alarm to indicate that a ground fault has not been cleared properly. This procedure is designed to give the operator an opportunity to carry out a course of action already decided upon for such conditions.

Fortunately the trend toward the use of resistors having a 2-min ground fault capacity allows reasonable time for disconnecting the source of trouble without opening or short-circuiting the resistor. Should either of these latter courses become necessary, however, it would seem preferable from a protection standpoint to maintain the system ground by short-circuiting the resistor, unless this action nullifies the purpose, such as prevention of telephone interference, for which the resistor originally was installed.

Grounding Transformers. Protection for grounding transformers of either the zig-zag or Y-Δ type should follow substantially along the lines indicated for grounding resistors and reactors in so far as the effects of sustained external ground faults are concerned.

For protection against internal faults 2 forms of differential protection may be used. In one of these, 3 differentially-connected overcurrent relays are operated in Y from the Δ-connected secondaries of 3 current transformers in the line side of the grounding transformers. This is equivalent to differential protection on an ordinary transformer at times when no load is being carried by the secondary, since in the grounding transformer the secondary Δ winding carries no external load; it provides protection against both turn-to-turn short-circuit and internal grounds occurring in the transformer or on the conductors between the transformer and the current transformers. The other method compares the zero phase-sequence currents on both sides of the grounding transformer by means of 3 line current transformers connected in parallel and balanced against a current transformer connected in the neutral. Since turn-to-turn faults do not result in zero phase-sequence currents this method does not protect against such faults but functions on faults to ground only. In applying these forms of protection it is important that the characteristics of the operating current transformers be checked up to maximum short-circuit values.

Impressions

In looking over the preceding recommendations one cannot fail to be impressed by the prominent place still occupied by the simple overcurrent relay in the protection of a wide range of electrical apparatus. Even where it has been supplanted in the first line of defense by more highly selective devices, it still is relied upon as a safeguard of last resort. Nor is this surprising when it is remembered that in any analysis of the destructive effect of dielectric rupture, the major damage is brought about by the thermal or magnetic effects of *high currents.* This thought tends to strengthen the belief that the persistence of the overcurrent relay as an important protective agent is destined to extend well into the future.

Growing interconnections have brought increasing problems to the operating engineer, and his demand for the rapid isolation of faults has brought similar problems to the relay designer. In recent years the trend has been toward the attainment of greater operating speeds with increased selectivity. However, progress in fields other than that of the relay also is to be recorded: Current transformers offering uniform characteristics up to exceptionally high currents are now on the way, and circuit breakers capable of interrupting these currents in a brief period of time already have been developed.

No discussion on protective methods can be complete without some reference to the primary position of the insulation itself. That improvements have been effected in apparatus insulation during recent years cannot be questioned; but there are quite obvious economic factors limiting the extension of the insulation to a point of absolute dependability under any and all conditions. Direct lightning strokes still are to be feared and the dangers from them cannot be overcome economically by increased insulation. Beyond the point at which greater insulation becomes impracticable the relay always must find its place in the protective economy of the electrical system.

Safe Harbor-Westport 230-Kv Transmission Line

Designed according to the latest ideas concerning lightning protection, the Safe Harbor-Westport 230-kv line is said to be the most heavily insulated so far constructed. Ground wire protection has been applied according to the latest theory, and special effort has been made to reduce tower to ground resistances.

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Reliability of transmission has been a matter of foremost importance in the design and construction of the 230-kv line connecting the Safe Harbor hydroelectric plant with the Westport steam station in Baltimore. This has been so not only because a large portion of the ultimate capacity (510,000 hp) of the Safe Harbor plant will be available for Baltimore, but also because during certain periods Baltimore will be dependent primarily upon Safe Harbor power.

Selection of high operating voltage was made only after a thorough investigation of (1) the relative economics and reliability factors involved, (2) the possibility of future interconnections, and (3) system stability. Studies made jointly with engineers of the Consolidated Gas, Electric Light and Power Company covered a comparison of 2 230-kv circuits with 6 110-kv circuits. These studies included also investigation of such problems as terminal location, 2-point versus single-point supply, the use or omission

Based upon "Safe Harbor-Westport 230-Kv Transmission Line" (No. 32M16) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10–13, 1932.

of high voltage buses, and amount of synchronous condenser capacity required. An a-c calculating board was employed to check the results obtained by analytical methods. The decision finally was made in favor of the higher voltage as offering lower cost, greater reliability, and greater possibilities for interconnection.

Routing of Line

Voltage regulation on the network in Baltimore, and control of short-circuit currents made advisable the delivery of power to each side of the city. As shown in Fig. 2, the present line circles the city and enters from the south; the second line as projected will terminate to the east of the city near the site of a future steam station. Routes for the 2 lines diverge on leaving the Susquehanna River and are so widely separated that the possibility of a lightning storm affecting both circuits simultaneously is almost non-existent. At present, Westport is the center of distribution in Baltimore; therefore, the termination of the line at this point called for less additional investment in distribution facilities.

Most of the terrain traversed by the line is rather rugged, and about 23 of the 70 miles is wooded. As the country is thickly settled, wire and railroad crossings are frequent. These include 4 66-kv and 12 railroad crossings, all of which increased the cost of wire stringing. The right-of-way is 150 ft wide and consists of part easements and part fee simple.

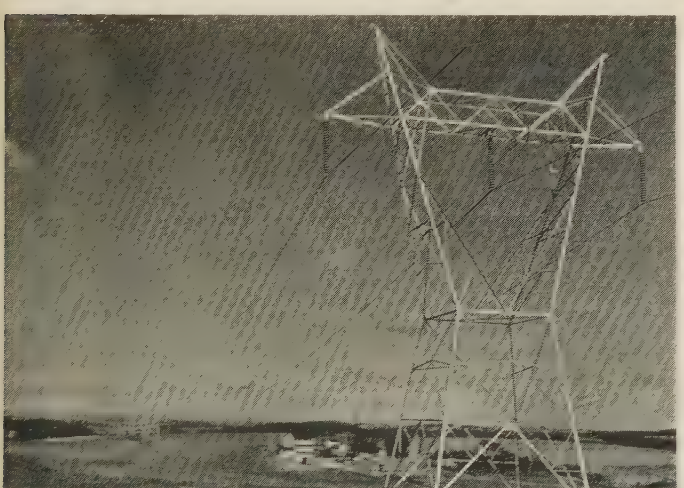

Fig. 1. A section of the line showing a type A tower in the foreground

Actual design and construction of the line were preceded of course by the usual preliminary surveys and detailed engineering studies. Lightning being considered the worst enemy of transmission lines in this part of the country, special design features were incorporated to minimize troubles from that source; these features include increased insulation, 20 10-in. suspension units with 5-in. spacing, and ground wires installed in accordance with the best design information available.

After the approximate location had been determined, and before the actual surveying of the property had begun, the route was photographed from the air, and the final route was laid out on a mosaic made to a scale of 1,000 ft per in. Later a profile was plotted from the United States Geological Survey map, from which the average span length and height of tower were determined. Final specifications were so drawn that the designers were not limited to any particular type of tower as designs submitted by manufacturers varied greatly in appearance and weight. A final selection was made from the various designs after a comparison on the basis of towers erected in the field. Details of some of the more interesting features of the line are given in the paragraphs that follow.

Towers

Originally 3 types of towers were used as a basis for design: type A for straight line and angles up to 3°; type B for angles from 3° to 15°; and type C for angles over 15° and for dead ends. Type A was modified to meet railroad specifications, the modified form being designated as type E. Later a transposition tower was brought out as type D.

As shown in Figs. 1 and 3, the towers are of the waist line type. (See "Load Test Check Tower Designs," by R. W. Wilbraham, *Electrical World*, Nov. 12, 1927.) This design gives the lowest footing reactions and by the use of body extensions permits variations in the length of leg with a minimum number of pieces. Sags and cable tensions were computed on the basis of N.E.L.A. heavy loading. In determining tower loadings one broken conductor

Fig. 2. Map showing routing of the Safe Harbor-Westport 230-kv line

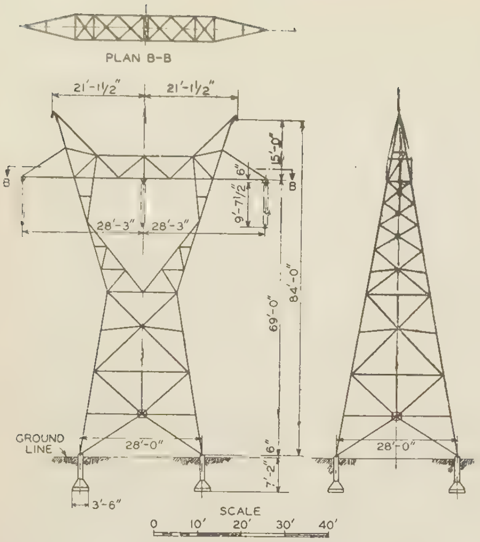

Fig. 3. Details of type A suspension tower

at a tension of 10,000 lb was assumed for "A" towers; dead end towers were assumed to have 3 broken conductors and 2 broken ground wires stressed to the elastic limit. All fittings are designed for a vertical load corresponding to one inch of ice on the conductors. Table I gives allowable stresses for design loadings. For test purposes all design loads were increased 25 per cent. Weights of the towers are shown in Table II.

Phase separation and length of crossarm were determined from the clearance diagram shown in Fig. 4. The ground wires were located so as to give maximum protection against a direct lightning stroke. Originally only 2 transpositions were contemplated. A third, however, was added at the request of another utility company. The original transpositions are somewhat unusual in that only 2 conductors are transposed at each point. This is sufficient to balance the conductors against each other but does not balance them against outside exposures; the transposition requested by the other utility was for this latter purpose and had to be complete. It was made by placing 2 transposition towers consecutively in the line.

For all but dead-end towers concrete foundations of the inverted mushroom type are used; these are designed for 100 per cent overload. This type of foundation can be built as cheaply as the grillage type; also it makes possible much closer alinement, resulting in a considerable saving in cost of erecting towers. Foundations for dead-end towers consist of angle iron stubs carried down to the bottom of the excavation and set in concrete. The average amount of concrete required for line towers is 4 cu yd; for dead-end towers 25 cu yd.

Conductors and Ground Wires

Before the final selection was made several types and makes of conductors were investigated, and their effects on spacing and height of towers studied. After comparing the various designs, a 795,000-cir mil A.C.S.R. (aluminum cable steel reinforced) conductor was chosen. The most advantageous combination of other metals considered would have required towers 5 ft higher than those designed for use with the conductor selected, would have been considerably higher in cost, and did not offer sufficient advantage to offset this difference in cost. Physical characteristics of conductors and ground wires are shown in Table III.

Table I—Allowable Stresses for Tower Design Loadings

Limiting Values of Slenderness Ratio	
Main members	150
Other compression members	200
Redundant members	250

Allowable Unit Stresses (lb per sq in.)	
Tension on net section	25,000
Compression (gross section)	$25{,}000 - 90\frac{L}{R}$
Shear on bolts	20,000
Bearing	40,000

Table II—Tower Weights in Pounds

	Type A	Type B	Type C
Tower	10,724	12,725	23,202
15-ft extension	2,941	3,275	5,761
30-ft extension			11,792
60-ft extension			33,320
Std. leg	189	326	568
−5-ft leg	142		
−2.5-ft leg	177	275	478
+2.5-ft leg	343	507	
+5-ft leg	393	569	920
+10-ft leg	678	944	
Anchor material	386	654	2,018

Conductor and ground wire tensions were held low (see Table III) in order to guard against vibration troubles. In addition, armor rods were provided at all suspension clamps. Sags and tensions were calculated from actual stress-strain curves as determined on tested samples 50 ft in length. During normal conditions, the sag of the ground wire is 5 ft less than that of the conductor. When loaded with $^1/_2$-in. of ice, these wires will parallel the unloaded conductors. Sags were adjusted without prestretching and are somewhat less now than they will be after being subjected to an ice load.

No effort was made to secure any special slip features in the suspension clamps as the J-bolts automatically limit the pressure on the conductor. Armor rods are secured by ovoid clamps which do not present any points or sharp edges to start corona streamers. Compression type clamps are used for all dead-ends and splices, the steel and aluminum being held separately. Dead-end towers are bridged by underslung bolted jumpers.

Insulators

Insulators at all suspension points are standard 10-in. suspension disks with 5-in. spacing. Suspension strings consist of 20 units and are doubled at all points where the load exceeds 4,500 lb. Clearances are provided for grading rings but none is used at the present time. On all dead-end towers double

strings consisting of 20 10-in. 25,000-lb strength insulators with $5^3/_4$-in. spacing are used.

Grounding

Ground wire protection is based upon a tower footing resistance of 50 ohms or less. A field check, however, showed that footing resistances varied from 1 ohm to 400 ohms with an average of 79 ohms; only 6 of the 351 towers had footing resistances below the 50-ohm limit.

Several different methods for reducing the ground resistance were investigated and some of them tested in the field. The method finally adopted as being most effective employs a 50-ft wire extending out radially from each corner of the tower, and buried about 20 in. below the surface of the ground. Each of these wires terminates in a salt treated grounding rod. The average resistance to ground of 4 wires and rods is 34 ohms. In a few cases the addition of these wires was insufficient to reduce the combined resistance to 50 ohms. Adding more wires in such cases proved rather disappointing, however, as the additional reduction amounted to only 10 or 15 per cent.

In order to determine the comparative effectiveness of a longitudinal counterpoise, about $4^1/_2$ miles of $^3/_8$-in. copperweld wire was buried along a section of line. As far as low frequency resistance is concerned, this proved less effective than 4 radial wires, and is more costly.

Special Features

Both the present and the proposed 220-kv lines to Baltimore are brought out from the upstream face of the power house, across the forebay to a hill on the east shore of the river. This hill will be the site of a future high-voltage switching station. On top of the hill the lines swing around to a river crossing on the downstream side of the power house. The distance across the river at this point is 5,725 ft. An island situated in mid-stream is used as a tower site and the crossing made in 2 spans of 2,880 and 2,845 ft, respectively. The hills on either side of the river are at el 500 and 450, while bed rock on the island is found at el 170.

High water in the river will reach el 190; hence any tower placed on the island must be set above this elevation to protect it against water and ice. Accordingly, the tower piers have been made heavy enough to withstand the maximum load expected from ice and water. To avoid building 2 sets of such piers, it was decided to place both circuits on one tower; this tower is 183 ft high, and has a spread at the base of 75 ft and a crossarm 146 ft long. The steel structure is carried down to bed rock where it is anchored with 24 2-in. bolts sunk 9 ft in the rock. The lower 25 ft of the tower legs are encased in concrete. The total weight of the tower is 180,000 lb.

Conductors in the crossing are 803,000 cir mils A.C.S.R. strung to a tension of 7,500 lb, and the ground wires 286,000 cir mils A.C.S.R. strung to a tension of 5,650 lb. Maximum tensions are 17,565 and 13,380 lb, respectively.

The problem of stringing this crossing presented some difficulties. The island was too narrow for a "reel set up" and therefore the cables had to be pulled from the shore to the island. Motive power was furnished by an electric power winch. The river bed at this point is full of submerged rocks so that the cables had to be kept above the water surface to guard them against injuries. The tension required to keep the cable from sagging down into the water however made it extremely difficult to pull the cable out. The problem was solved by stringing a $^5/_8$-in. steel messenger cable and trolleying the conductors over on the messenger.

The line was built during a period of low material

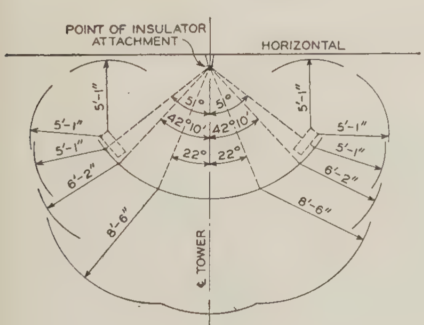

Fig. 4. Clearance diagram for type A tower

Table III—Characteristics of Conductors and Ground Wires

	Conductor	Ground Wires
Size A.C.S.R.	795,000 cir mils	203,200 cir mils
Per cent steel	39.5	71.9
Stranding	30x0.1628-in. al. / 19x0.0977-in. steel	16x0.1127-in. al. / 19x0.0977-in. steel
Diameter	1.140 in.	0.714 in.
Weight per foot	1.234 lb	0.6785 lb
Ultimate strength	37,770 lb	26,600 lb
Elastic limit	27,250 lb	18,620 lb
Tension at assumed maximum load ($^1/_2$-in. ice, 8-lb wind, 0° F)	12,000 lb	9,060 lb
Tension at 60° F	6,175 lb	4,180 lb

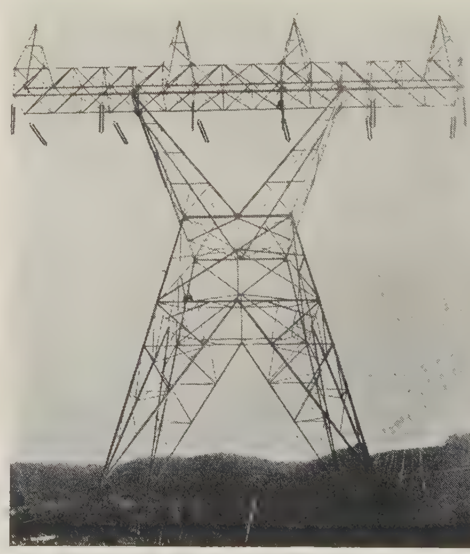
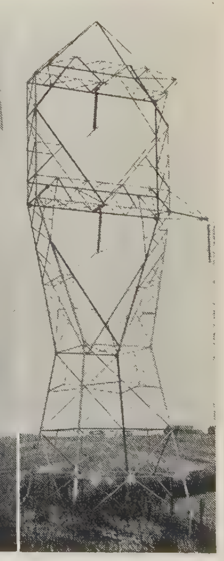

Fig. 5. (Right) Type D transposition tower

Fig. 6. (Left) Double circuit river crossing tower on island just below the Safe Harbor plant

prices and plentiful supply of labor. The right-of-way department kept well ahead of construction so that work, when once started, proceeded without delay. Actual field work began March 1, 1931, and the line was turned over to the operating department December 4, 1931, 9 months and 4 days after the work was initiated. Mechanical equipment kept the organization small (150 men maximum) and helped to speed up the work.

Much has been said about the frailty of A.C.S.R. and about the precautions needed to protect it against damage. The Safe Harbor-Westport line was strung without any special safeguards, yet it stands completed with only 3 repair sleeves, 2 of which could have been left off. In addition to these, about 150 ft of cable had to be cut out because of damage when a conductor jammed in a roller block which had not been closed properly.

Pulp Insulation for Telephone Cables

After some 40 years of service spirally wrapped paper insulation is rapidly being displaced for interoffice and subscriber loop cables, by a pulp insulation applied directly to the conductor by a process which brings the paper mill into the cable plant and combines the paper making and insulating operations into one process with the elimination of a number of costly intermediate steps. In addition, this process makes possible the use of a less expensive material as an insulating medium.

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INSULATED wire of a type considerably cheaper than paper ribbon insulation has been developed. The insulation is formed from paper pulp directly on the conductor by a special type of paper-making equipment. This equipment is not critical to the kind of pulp used but for the purposes of durability, strength, and economy a Kraft wood pulp has been used in telephone cables. The process has progressed through the development stage and is now in continuous operation in the commercial production of all the principal exchange area cables of 24 and 26 A.W.G. conductors used in the Bell system. (Fig. 2.) Thousands of miles of lead-encased pulp insulated cables, ranging in size from the smallest consisting of 11 pairs to the largest consisting of 1,818 pairs, are now giving satisfactory service and because of the substantial economies which the construction promises for the finer wire cables, attention is being directed toward its possible application to larger gage cable conductors and to its use as an insulating medium for other electrical circuits.

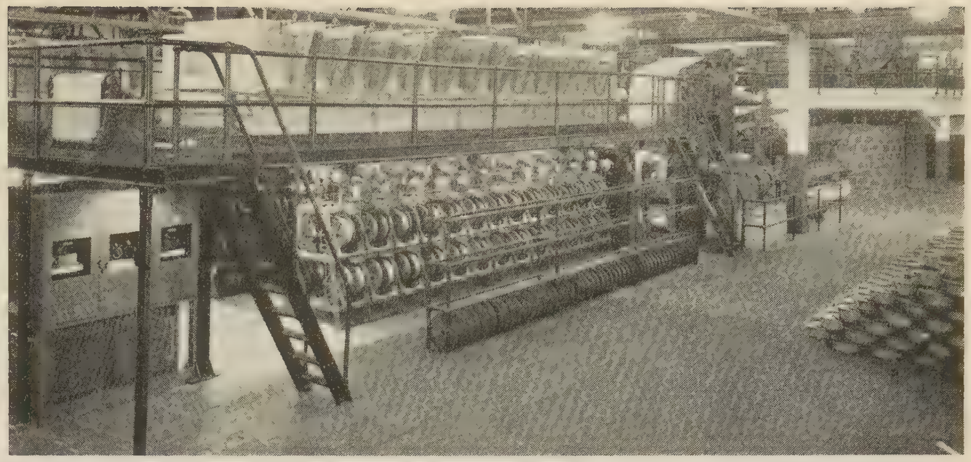
For many years conductors for lead-sheathed telephone cables were insulated by helically wound strips of paper made from a stock composed of all old rope, or old rope and a small admixture of cotton. In an effort to find a suitable less expensive fiber, however, a formula composed of about 40 per cent chemical wood pulp and the remainder rope stock was adopted in 1920 for the larger sizes of paper only. This wood fiber is of the spruce or other coniferous tree species prepared by the sulfate or Kraft process. Extensive tests have demonstrated that it compares favorably in stability and permanence with the well-established manila fiber. In the case of the newly developed pulp insulated cable, the raw material used is 100 per cent Kraft wood fiber.

Work was initiated in 1921 to determine the possibilities of producing a continuous homogeneous paper covering directly on the wire. Preliminary tests were sufficiently interesting to warrant proceeding further with the project. A 10-wire machine was started up in 1924, with very indifferent success, but succeeding developments in technique and improvements in equipment resulted in a product so satisfactory that the machine was expanded to a 50-wire capacity and put in operation early in 1928. In 1931, 10 more wires were added. The product was cabled into 26 and 24 A.W.G. cables on standard cabling equipment with no major difficulties, and installed in commercial telephone plant by

Fig. 1. Wire supply and pulp preparation equipment

Based upon "Pulp Insulation for Telephone Cables" (No. 32-122) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., October 10–13, 1932.

Fig. 2. General view of pulp insulating equipment. The take-up and dryer are shown in the left foreground; the polishers and wet machine in the right center; and the wire supply and pulp preparation equipment in the right background



the operating companies. No serious operating trouble has developed in any of this cable.

The pulp insulated wire capacity now at the Hawthorne and Kearny plants is approximately 225,000,000 conductor feet per week and all 24 and 26 A.W.G. exchange area cables are being manufactured from pulp insulated wire.

Process of Manufacture

The insulating material which is to be placed on the wire is given practically the same treatment in a beater as it would receive in paper making, but without the addition of sizing or loading. The beaten pulp is stored in a large tank from which it is pumped to a mix box for dilution with water before passing to the screen where coarse particles and lumps are removed. (Fig. 1.)

For the next operation a modified paper machine of the cylinder type is used. The mixture of pulp and water is fed into the cylinder vat by gravity from the screen. The cylinder mold itself is divided into 60 narrow uniform sections by dams or deckles on the surface of the wire cloth covering. The bare conductors coming to the machine are guided so that one conductor passes around the mold in each of the sections. As the mold is rotated in the water suspension of pulp in the vat, a narrow continuous sheet of paper with a conductor embedded in it is formed in each section by the simple paper making process of straining the fibers from the suspension as the water flows through the fine wire cloth covering the mold, under the slight head maintained outside the mold. These sheets are transferred from the mold to a woolen felt by the pressure of a couch roll and carried by it through 2 presses which take out a considerable part of the water and leave the material in shape to be turned down to the final form. This is done by passing the conductors embedded in the narrow sheets through individual polishers which turn the wet sheet down into a uniform covering of a size determined to a large extent by the amount of pulp deposited in the sheet. These polishers are simply rapidly rotating heads carrying 3 specially shaped blades so arranged that 1 blade deflects the traveling wire and sheet from a straight line against the other 2, with a pressure controlled by the tension on the wire.

The wet cylindrical insulation is then dried to about a 9 per cent moisture content by a single passage through a horizontal electric furnace 26 ft long, the wet end of which is maintained at a temperature of about 1,500 deg F and the dry or tempering end at something under 800 deg F. The wires are carried through the drier by a rotary pulling mechanism designed to minimize the crushing or flattening of the dried insulation. This device delivers the finished product to the take-ups for spooling. The machine is operated at about 130 ft per min.

Considerable amounts of water are used in the process, for in this, as in all paper making processes, water acts not only as a carrier for the fibers, but it forms some sort of a loose chemical or mechanical combination with them in the beater and is one of the principal factors in determining the final characteristics of the material. The approximate fiber concentrations at the various steps of manufacture are given in Table I.

In theory the whole process is remarkably simple, but from the practical standpoint many intricate problems had to be solved before satisfactory operation was possible. Means, for example, had to be worked out for shifting from an empty spool of wire to a full one without shutdown or break in conductor or insulation. Also methods of restringing broken wires with the machine in operation had to be developed. Continuous 6-day week operation now is possible without shutdowns except for the midweek clean-up. The satisfactory working out of many other details also was necessary to secure the present smoothness of operation.

Table I—Approximate Fiber Concentrations

Step in Manufacture	Per Cent	Step in Manufacture	Per Cent
Beater	3.5-4	Cylinder vat	0.05
Storage	1.3	Polishers	28
Screen	0.07	Completed insulation	91
		Finished cable	100

Physical Characteristics

The physical characteristics of pulp insulation, some of which are shown in Table II, may be modified

somewhat by choice of materials and methods of manufacture, but they cannot be controlled entirely. The comments which follow cover only the sizes which have been run almost exclusively to date, namely 24 and 26 A.W.G. wire, but it should be noted that wires ranging in size from 19 to 28 A.W.G. have been covered successfully.

The physical characteristics shown in Table II are controlled by the beating of the pulp, the amount of pulp fed to the machine, the dryness of the sheet in the polishers, and the speed of drying. The tensile strength and flexibility of the insulation can be varied through wide limits by different treatments during manufacture. The elongation is quite comparable to that of ordinary paper and is not susceptible of much variation. The insulation is made sufficiently strong and flexible to withstand the various operations incident to cable fabrication and subsequent handling yet not so tough that it cannot be readily removed from the wire at the point of splicing.

Table II—Some Physical Characteristics of Pulp Insulation

Characteristic	Range of Values Obtainable
Diameter of insulated wire—inches	0.030 to 0.050 for 24 A.W.G. 0.026 to 0.040 for 26 A.W.G.
Weight of dry pulp—grams per foot	0.045 to 0.12 for 24 A.W.G. 0.040 to 0.095 for 26 A.W.G.
Density—ratio of fiber to total volume	35% to 55%—independent of gage

The surface of the insulation has a rather rough blotting paper appearance, though some variation is possible by changes in the beating. The cross-section is circular with the conductor in the center in the ideal case, but because of limitations imposed by practical operating considerations there is a tendency toward some eccentricity and flattening of the insulation.

Design of Pulp Insulated Cables

Telephone cable circuits are normally subjected to only a low dielectric stress; this permits their being placed in close proximity to one another. Thus the primary requirement of the insulation is that it be distributed in a thin layer of uniform application, with the wire well centered so that each conductor when packed into a cable is completely insulated from its neighbors throughout its length. The mean radial thickness of the pulp insulation for the 26 A.W.G. wire is less than 0.01 in., and for 24 A.W.G. wire is about 0.01¼ in. The pulp is prepared and applied to the conductor in such a manner that the fibers pack together to form a cover with sufficient strength and elasticity to withstand the handling the insulated wire must receive and yet be as light as possible in weight per unit volume in order to obtain the best electrical characteristics.

Pulp insulated wire is structurally more like textile insulated wire than air spaced paper ribbon insulated wire. The insulation is firm with no appreciable air gap between it and the wire, and bundles of wires nestle together differently when grouped into a given space. Furthermore, it was found that when pairs of conductors were stranded together in the usual manner of concentric layers each reversed in direction, the unit thus formed was considerably less flexible than the standard construction. This is apparently caused by the greater frictional resistance between layers, thus causing sharp kinks for even moderate bends. While this feature is less pronounced for small cables, it is, of course, objectionable and an improvement in the handling qualities is effected by stranding several layers in the same direction rather than employing the single reverse layer construction.

For the large size cable, a design whereby the pairs are first grouped into units of 51 or 101, all the pairs in these units being stranded in the same direction and the units then stranded together into a cable, gives a construction which seems to offer the most satisfactory arrangement. Thus, for example, a 1,212-pair cable is made up of 12 units of 101 pairs each, arranged with 4 units in the center and 8 in a surrounding layer, and an 1,818-pair cable is laid up with 2 units in the center surrounded by 6 units in the first layer and 10 units in the second layer. A short section of 1,818-pair 26 A.W.G. cable with the units separated is shown in Fig. 3. One might expect these rather large units would not group themselves together into a circular shape without poor utilization of the space they occupy but it has been found that by properly constructing the individual units and by suitable arrangement of the cable layup, a cross-section is obtained with the groups keystoning together nicely and presenting no noticeable voids.

Fig. 3. Section of 1,818-pair 26 A.W.G. cable showing units separated

The cable core must also have a certain firmness or density to give the best support to the sheath and insure satisfactory handling as the cables are being installed. With ribbon paper insulation the ratio of the amount of insulation to the non-copper space in a cable was found to be a fairly good criterion of the firmness required. With the fundamentally different physical characteristics of the pulp insulated wire this relationship was altered and experimental trials were therefore necessary to determine the approximate size of pulp insulated wire most suitable for the space it was to occupy in cable form. There is

some latitude here in the distribution of a given amount of fiber but taking into account both the mechanical and electrical requirements, the diameter for the insulated conductor finally selected as the most satisfactory for the series of standard cables of 24 A.W.G. was 0.041 in. and for 26 A.W.G., 0.033 in.; and the aim in manufacture is to produce an insulation as uniformly close to these dimensions as possible. These diameters are measured by a volume displacement method. Short samples, as representative as possible of the wire under consideration, are inserted for a given distance into a small bore tube of mercury and the displacement noted. The gage is calibrated so that mean diameters are read directly on the scale.

The above specific sizes of pulp insulated conductors apply only to cables designed for a particular set of characteristics. As in the case of ribbon paper cables, the amount of insulation for a given gage of conductor may be varied within reasonable limits, so as to produce cables of other characteristics.

Electrical Characteristics

It was reasoned that pulp insulated cables would probably be inherently higher in mutual capacitance than similar sizes of paper ribbon cables because, considering the insulated wire itself, in the case of helically applied strip insulation the volume of air beneath the paper is about equal to the volume of the paper itself, while for pulp insulation there is very little air space between the insulation and the wire. This fundamental difference could be somewhat compensated for, however, by the introduction of more air into the spaces between the fibers of the pulp insulating medium than is found in the paper ribbon itself, but it was not expected that it would entirely neutralize the effect of lack of air space next to the wire. It was appreciated, however, that the aim should be to get as low density insulation as possible still consistent with obtaining a continuous, flexible, and strong covering on the wire and emphasis was placed on this phase from the start of the development. In Fig. 4 is shown graphically the progress

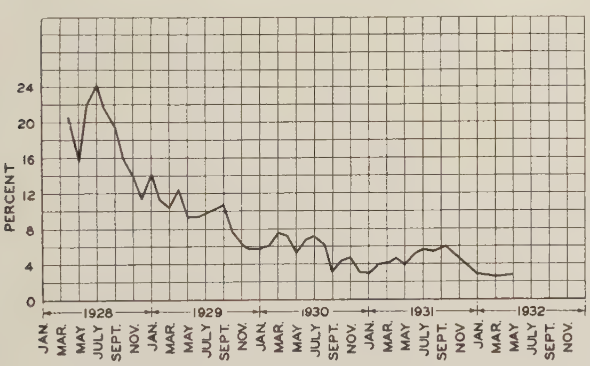


Fig. 4. Curve showing improvement in mutual capacitance since early 1928

The percentage is that by which the capacitance of 24 A.W.G. pulp insulated cables exceeds that of ribbon insulated cable

that has been made in reducing the mutual capacitance of 24 A.W.G. cable since early in 1928. Although a substantial improvement has been made in lowering the mutual capacitance to within less than 4 per cent of the corresponding ribbon paper cable, a further reduction would have considerable value, warranting more effort in that direction. For 26 A.W.G. cable the excess in capacitance is even less than for 24 A.W.G., and furthermore, it is not so objectionable from a transmission standpoint as in the case of the larger gage.

The principal factors which have brought about this reduction in capacitance are improvements in the treatment of the pulp itself, refinements in machinery operation to permit the use of a lower density covering on the wire, the more rapid drying out of the moisture from the pulp resulting in less shrinkage of the insulation on the conductors, and the producing of more nearly round and better centered insulation. Of these factors perhaps the one having the greatest effect on lowering the mutual capacitance was that of improving the out-of-roundness of the insulated conductors. In studying this phase of the problem, advantage was taken of the effect of flatness of the insulation on the component parts which make up the mutual capacitance. The mutual capacitance of a pair of wires is composed of the direct capacitance between the 2 wires augmented by a series arrangement of 2 other direct capacitances, one from each of the 2 wires to the grounded group consisting of all other wires and sheath. As 2 wires with oval shape insulation are twisted, there is a decided tendency for 2 flat sides to stay together resulting in the average separation of wire and mate being less than where circular sections are involved. To determine accurately the degree of out-of-roundness representing the average condition throughout a length of cable by mechanical means is next to impossible, whereas the direct capacitance between wire and mate automatically integrates this condition. Measurements therefore are made of the component direct capacitances and their ratio used as a sensitive indicator of the effect of flatness of the insulation on the mutual capacitance. By using the ratio of capacitances the cable length error is eliminated and accurate determination can readily be made on short lengths of cable. In Fig. 5 and Table III are given data which were obtained on 4 short lengths of pulp insulated

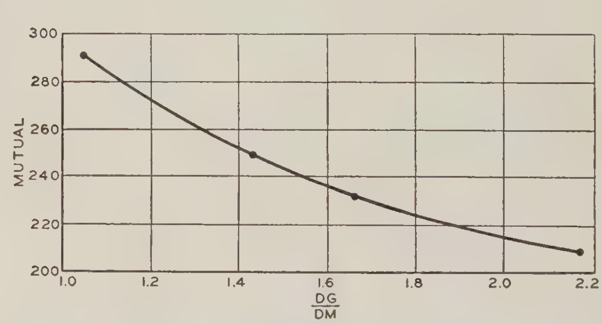


Fig. 5. Curve showing mutual capacitance versus direct capacitance to ground divided by direct capacitance to mate

cables which so far as was known differed only as regards the lack of symmetry of the insulation.

The a-c mutual conductance follows the trend of the capacitance, resulting in the ratio of conductance to capacitance at a frequency of 900 cycles per sec being somewhat higher than the standard ribbon paper cable, but not of a magnitude such as to introduce any serious transmission loss for these fine gage circuits. The d-c insulation resistance is of the same order as that of strip paper cables.

The dielectric strength of the insulation is ample, being somewhat higher on the average than that of similar strip paper cables. A rather extensive series of mechanical tests comparing pulp and ribbon types of insulated cable under controlled conditions simulating those met with in actual installation, showed that the pulp insulated cables remained superior to the ribbon cables as regards dielectric strength but that under extreme loads they would not withstand quite as much stretch as the ribbon insulated cable without mechanical damage to the insulation.

Installation Features

No new features are involved in installing pulp insulated cable except in the splicing of the conductors after the lengths as supplied from the factory have been placed in position in the plant. This operation, however, is a considerable factor in the total time of the installation procedure because in a not unusual run of a mile of an 1,818-pair cable, there may be as many as 40,000 joints to be made involving the stripping of twice that number of ends of insulated wire preparatory to joining the copper conductors.

Immediately upon removing the lead sheath from the ends of the cables thus exposing the dry insulation to the atmosphere, absorption of moisture rapidly takes place. It is customary therefore to boil out the ends of cable with paraffin wax before starting the splicing operation. With strip insulation this wax also aids in preventing the insulation from unfurling. It was found that even the most flexible pulp insulation so far produced, when impregnated with unmodified paraffin, would not withstand satisfactorily the handling incident to splicing at low temperatures. A softer and more lubricating type of compound is required and a suitable combination has been found by adding paraffin oil to the paraffin wax. Different proportions of oil and wax are used depending upon the temperature at the time of installation, and the compounding is done at the point of splicing. At an atmospheric temperature of about 75 deg F no oil is required and below 10 deg F about half oil and half wax makes a suitable compound with proportionate amounts of oil for intermediate temperatures. In Fig. 6 is shown the stripping characteristics of typical pulp insulation on a few inches of 24 A.W.G. conductor impregnated with compounds of different proportions of paraffin wax and oil.

Table III—Capacity Measurements Indicating Symmetry

Mutual Capacitance vs. $\frac{\text{Direct Capacitance to Ground}}{\text{Direct Capacitance to Mate}}$

Average Value in $\mu\mu$f.

Sample	Mutual	D_M	D_G	D_G/D_M
1	292	187	201	1.07
2	250	144	207	1.42
3	233	126	209	1.66
4	206	101	221	2.19

In starting to make a splice, the insulated conductors are brought together in proper position, given a sharp crossover, the wires cut off so as to give several inches of free end, the insulation broken at the crossover, and then stripped off the ends. Thus the ideal insulation is one which when waxed can readily be parted at the crossover and when broken will slip freely along the wire, yet will withstand considerable bending and folding at other places in the splice without breaking. Pulp insulation tends to cling to the conductor somewhat more than a paper tube of strip insulation and although there is considerable variation in this characteristic in the product as now manufactured, it is sufficiently under control so that with a small amount of experience a splicer applying his usual technique is able to handle even 26 A.W.G. wire with little breaking of the conductors. There is, of course, with pulp no raveling of the insulation and the cotton sleeves which are used to insulate the joint, slip over the ends of the wires rather more readily than for the spirally applied paper. Thus the over-all time required for joining a given number of pairs is practically the same for the 2 types of insulation.

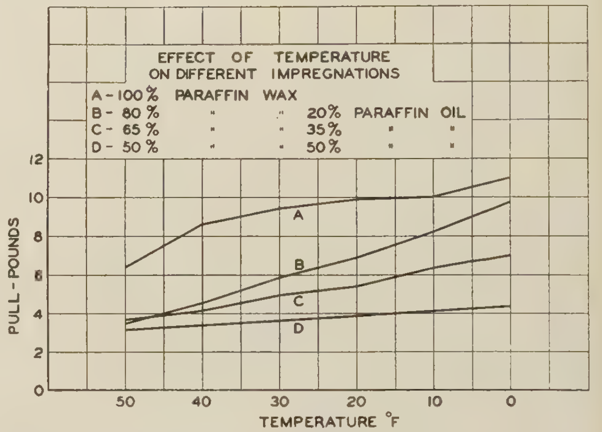


Fig. 6. Curve showing effect of atmospheric temperature on pull required to strip insulation impregnated with various wax and oil mixtures

An unbleached pulp is used and the natural brownish color of the Kraft stock results in less sharp color distinction for the different groupings of pairs than where ribbon insulation is used. However, by simplifying the color code so as to require only red, blue, and green, besides the natural color, sufficient contrast in the shades is obtained so that there is no difficulty in distinguishing colors in the splicing operation.

Preliminary cost figures indicated that this process

offered the possibility of a considerable saving over the ribbon process. These predictions have been verified by actual machine operation extending over a period of more than 3 years. The savings are made possible by the low cost of Kraft pulp as compared with manila paper and by the elimination of the intermediate paper making, paper slitting, and handling operations.

Dynamic Braking of Synchronous Machines

Accurate and practical formulas for determining the number of revolutions and time required to stop a synchronous machine by dynamic braking are presented in this article, thus enabling the prediction of dynamic braking performance comparable with that of other machine characteristics. The method is new to the extent that it treats variable speed short circuits.

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ROTATION of synchronous machines frequently must be stopped as quickly as possible. The electrical methods of accomplishing this are plugging and dynamic braking. Plugging consists of reversing the phase rotation of the voltage applied to the armature winding. Dynamic braking consists of short-circuiting the armature through an external resistor and maintaining field excitation. Following a comparison of these 2 methods, the results of an analytical treatment of dynamic braking are given.

Independent of the type of braking used, the stored energy in the rotating system must be converted into some other form, usually heat. Analyses of a number of particular applications of synchronous motors to steel and rubber mills, where quick stops are necessary, have shown that practically all of the stored energy in such systems is in the motor rotor. The normal means of dissipation of this energy are the windage, friction, copper and core losses of the motor, and the friction of the rolls. Generally, unless the rolls are loaded, the amount of energy dissipated in them is negligible, being of the same order of magnitude as their stored kinetic energy. The neglect of both these factors is therefore a compensating error. The other means of energy dissipation are functions of the method used.

In plugging, the phase rotation of the supply voltage is reversed, the performance then being similar to that during starting except that the motor slip varies from two to one instead of from one to zero. At the time the speed becomes zero, the power must be removed to prevent a reversal of rotation. This method of phase reversal is subject to several outstanding objections, the most prominent of which are:

1. Unless the power supply is large, the system disturbance resulting from the switching operations may be very undesirable.

2. The torque developed for a usual motor is small, thus limiting the rate at which the system can be stopped unless a specially designed amortisseur winding is used. This special design of amortisseur winding, beneficial to stopping, frequently is detrimental to other machine characteristics.

3. If reversal is to be prevented, the power supply must be controlled accurately so that it may be removed at the instant the motor reaches zero speed. This introduces complications in the control circuits which can be avoided by other stopping methods.

In dynamic braking the armature is short-circuited through an external resistor and field excitation is maintained. The operation is that of a generator short-circuited through an external resistor. The theory of such operation from the standpoint of constant speed has been treated thoroughly in previous publications. The dynamic braking cycle differs from these treatments in that as the rotational energy of the system is dissipated, the speed of the machine decreases. The rate of this dissipation depends greatly upon the resistance used, as will be shown.

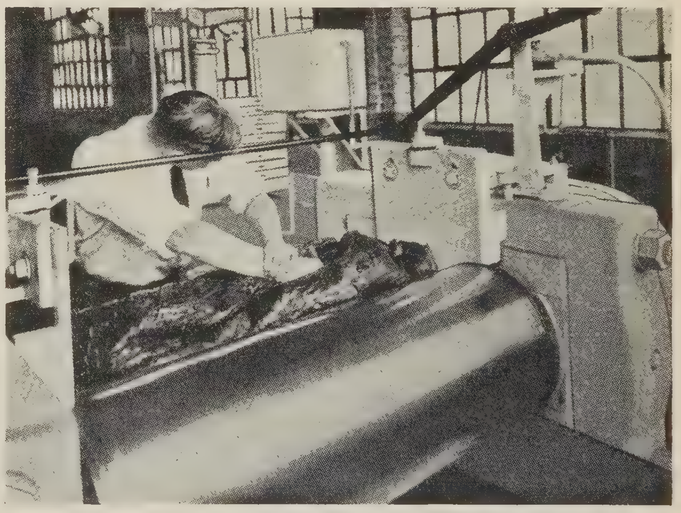


Fig. 1. A typical application where rapid braking is necessary

In order to present a comparison of the 2 methods, Table I has been prepared showing the number of revolutions made before stopping and the time in

Full text of "Dynamic Braking of Synchronous Machines" (No. 32-67) presented at the A.I.E.E. summer convention, Cleveland, Ohio, June 20–24, 1932.

seconds required for each of the 2 methods. The figures are based on an average 1,000-hp unity-power-factor, mill-type motor. They represent calculated results based on the theory which follows.

Analytical Relations

To determine the relations during the braking cycle an expression for the instantaneous armature current is obtained from the vector diagram of a suddenly short-circuited generator with known speed decrease. The instantaneous torque in synchronous kilowatts is obtained from the armature current and effective circuit resistance. This is equated to the rate of change of kinetic energy due to speed reduction. There results a differential equation which when solved gives the speed-time curve in terms of the machine constants. Experience has shown that there are 2 satisfactory methods of solving this equation. The first, based upon the assumption of constant effective excitation, gives an equation for the speed-time curve as follows:

$$t = \frac{2H}{e_d'^2 r}\left\{\frac{x_d'^2}{2}(1-n^2) - r^2 \log n + \frac{r^2}{2}\left(\frac{x_d'}{x_q} - 1\right)^2 \log \frac{n^2 x_q^2 + r^2}{x_q^2 + r^2}\right\} \quad (1)$$

where

t = time in seconds
H = stored kinetic energy in kw-sec per unit normal kva
e_d' = excitation behind transient reactance at the instant of applying the short circuit
r = total internal and external armature resistance
x_d' = direct axis transient reactance
n = per unit speed
x_q = quadrature axis synchronous reactance.

The number of revolutions made by the machine upon reaching a given speed is then obtained by changing the variable in the speed-time equation and integrating. This is:

$$R = \frac{N_0 H}{30 e_d'^2 r}\left\{r^2(1-n) + \frac{x_d'^2}{3}(1-n^3) - r^2\left(\frac{x_d'}{x_q} - 1\right)^2\left[(1-n) - \frac{r}{x_q}\left(\tan^{-1}\frac{x_q}{r} - \tan^{-1}\frac{nx_q}{r}\right)\right]\right\} \quad (2)$$

where

R = total revolutions up to any time
N_0 = revolutions per minute at synchronous speed.

The total revolutions made to stop are found by placing correct boundary conditions in the above equation, and solving. The result is:

$$R_s = \frac{N_0 H}{30 e_d'^2 r}\left\{r^2 + \frac{x_d'^2}{3} - r^2\left(\frac{x_d'}{x_q} - 1\right)^2 \times \left(1 - \frac{r}{x_q}\tan^{-1}\frac{x_q}{r}\right)\right\} \quad (3)$$

where

R_s = total revolutions to stop.

The optimum value of resistance to be used in order that the revolutions to stop are a minimum, considering all of the machine quantities to remain constant, is obtained by differentiating R_s with respect to r and neglecting the less significant terms. This value is:

$$r_0 = \frac{x_d'}{\sqrt{3}}$$

The second method of solution is based upon variable excitation with an assumption regarding the manner of variation. Analysis of a number of oscillograms taken during the dynamic braking cycle has shown that the field current can be represented very closely by a single exponential form, the time constant however being shorter than that of the field under short-circuited armature conditions.

Table I—Revolutions and Time to Stop

Motor Speed r.p.m.	Plugging Rev.	Plugging Time (Sec)	Dynamic braking Rev.	Dynamic braking Time (Sec)
1,200	15.60	1.72	9.00	0.98
600	5.50	1.21	4.32	0.95
300	2.90	1.28	2.40	1.05
150	1.65	1.45	1.41	1.24
72	1.02	1.87	0.85	1.56

Using this assumption there results a relation between the machine quantities, speed and time, as follows:

$$\frac{E_f^2}{r_f^2}t - \frac{2E_f\left(I_B - \frac{E_f}{r_f}\right)}{r_f\,\alpha}(\epsilon^{-\alpha t} - 1) - \frac{\left(I_B - \frac{E_f}{r_f}\right)^2}{2\alpha}(\epsilon^{-2\alpha t} - 1) = \frac{2HI_{of}^2}{r}\left\{\frac{x_d^2}{2}(1-n)^2 - r^2\log n + \frac{r^2}{2}\left(\frac{x_d}{x_q} - 1\right)^2 \log\frac{n^2x_q^2 + r^2}{x_q^2 + r^2}\right\} \quad (4)$$

where

E_f = volts, field
r_f = field ohmic resistance

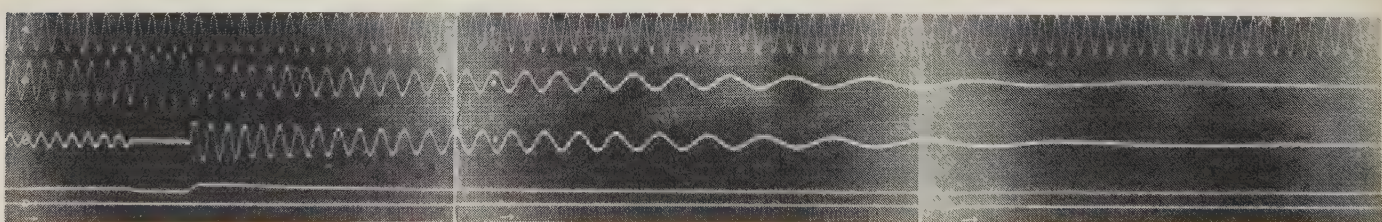


Fig. 2. Dynamic braking cycle of a synchronous motor

Curve *A*—60-cycle timing wave   Curve *B*—terminal voltage   Curve *C*—armature current   Curve *D*—field current

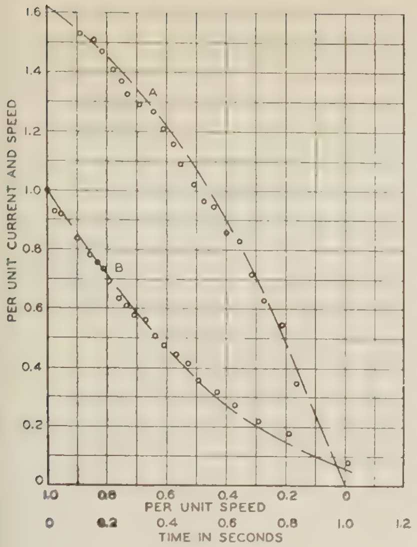


Fig. 3. (Left) Current and speed characteristics during the braking cycle shown in Fig. 2

Curve A—per-unit current vs. per-unit speed

$$i_n = e_d' \left\{ \frac{x_q^2 + \left(\frac{r}{n}\right)^2}{\left(\frac{r}{n}\right)^2 + x_d' x_q} \right\}^{1/2}$$

where i_n is per-unit armature current at per-unit speed

Curve B—per-unit speed vs. time. (See eq. 1)

Test points indicated by small circles

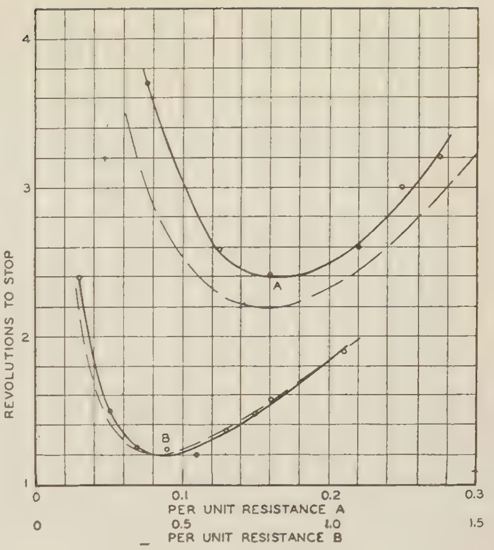
Fig. 4. (Right) Effect of external resistance on stopping revolutions

Curves A—600-hp, 12-pole, 600-rpm, 0.8-power factor motor

Curves B—500-hp, 40-pole, 180-rpm, 0.8-power factor motor

Test curves in full lines

Calculated curves in broken lines. (See eq 3)



I_B = field amperes after disconnecting from line
α = apparent decrement factor of field decay
I_{fo} = amperes field to produce normal open circuit terminal voltage on air-gap line
x_d = direct axis synchronous reactance.

The left hand side of the equation has only time functions, and the right hand side has only speed functions. Being of transcendental character, no explicit solution is available, but the desired result may be obtained by plotting the 2 sides of the equation and finding the time and corresponding speed for which they are equal.

Discussion of Results

The theoretical results are based on the premise that saturation may be neglected, but their application to a practical machine must include saturation effects in the determination of the initial conditions and in the determination of the instantaneous excitation. This is evident, because regardless of the initial terminal voltage applied, and the initial field current, there is some point during the speed decrease at which normal flux is reached. As the machine passes this point, saturation plays an increasingly greater part in the effective excitation. Since this excitation enters the determination of the stopping revolutions as the square, its accurate calculation is imperative. Satisfactory results would not be possible in many practical applications if saturation were omitted.

The assumption of constant effective excitation will embrace a large majority of applications, in fact will be sufficiently accurate for most calculations.

In the case of a braking cycle being initiated with the machine under load, it is interesting to note that the revolutions to stop, due to the rate of electrical energy dissipation will usually be greater than would occur under initial no-load conditions. The presence of the shaft load, if it continues, will of course aid in the stopping and bring the machine to rest sooner than the no-load condition in spite of the fact that the rate of electrical energy dissipation is less.

The effect of corrective power factor is to increase the effective excitation and consequently improve the stopping cycle. If, however, the power factor necessitates a larger diameter machine than could otherwise be used, the increased mechanical energy storage may more than offset the gain obtained from a greater rate of dissipation. The proper proportioning of a particular machine depends upon these 2 factors, and to obtain good results a careful balance must be found.

Comparison Between Test and Calculated Results

In Fig. 2 is shown an oscillogram of the relations during the dynamic braking of a 500-hp, 40-pole, 180-rpm, 0.8-power factor synchronous motor whose constants are:

x_d = 1.45 x_q = 1.02 x_d' = 0.65 e_d' = 1.34 N_0 = 180
H = stored energy per kva = 0.493 second
r = total per-unit armature resistance = 0.53

In Fig. 3 is shown a comparison between test and calculated current-speed and speed-time curves from the oscillogram of Fig. 2. The agreement between the curves is quite satisfactory. Fig. 4 shows test and calculated revolutions to stop vs. per-unit armature resistance on 2 synchronous motors, one of which is the one given previously and the other is a 600-hp, 12-pole, 600-rpm, 0.8-power factor machine whose constants are:

x_d = 0.89 x_q = 0.52 x_d' = 0.22 e_d' = 1.27
H = 0.762 N_0 = 600

The general shapes of the test and calculated curves are similar although there is a fairly constant difference between the curves on the 12-pole motor.

Of particular interest is the fact that the agreement between test and calculated values at the optimum resistance is quite good. This is true of the revolutions to stop as well as the current-speed and speed-time curves. As the resistance is increased or decreased with respect to the optimum the agreement is less satisfactory. The minimum revolutions as determined by the equation for r_o are 2.45 for the 12-pole motor and 1.22 for the 40-pole motor. The test curves give respectively, 2.42 and 1.20.

Economic Aspects of Water Power

Among developments of the past decade that have enhanced the usefulness of hydroelectric power are the present large size of electric utility systems, the peaked nature of their loads, advances in long distance power transmission, and various improvements in the design and construction of hydroelectric plants. In this article the value of water power is analyzed in terms of the 2 main components of the cost of steam power—capacity and energy.

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DURING THE PAST DECADE, water power in all those regions of the North American Continent where it is employed in conjunction with thermal sources of power has undergone a gradual but pronounced change in its economic relationship to steam power. Two main components make up the economic value of water power—capacity and energy. The capacity value of hydroelectric plants, that is the cost of procuring equivalent capacity service by other sources of power, so far has not been affected measurably by advances in the art of constructing thermal plants; but the energy value or the cost of producing energy by other means has been reduced greatly in recent years.

This downward trend in energy value may be traced chiefly to 2 causes: improvements in thermal economy and the declining price of fuel; and in a minor way only to miscellaneous causes such as reduction in maintenance cost and operating labor due to improvements in design, and concentration of large capacity in comparatively few units. There is some well warranted expectation that the future trend of average fuel prices will be decidedly upward, but probably not sufficient to overbalance materially the effect of further improvements in thermal economy that may be realized in the future.

Since the total energy output for a given water power site is limited by natural conditions of discharge and head, the gain in energy output due to various refinements in the efficiency of energy conversion is necessarily only of minor importance. It is evident, therefore, that the most fruitful field of endeavor for enhancing the economic value of water power will lie in the direction of (1) reducing the investment cost per kilowatt to a point where the carrying charges will compare favorably with equivalent cost of steam power; and (2) increasing the total amount of economically installed capacity beyond the formerly accepted limits and coordinating the operation of the combined sources so that such additional economic hydroelectric capacity can be utilized to render firm peak service to the power supply system of which it is a part.

The purpose of this article is to review briefly the parallel developments in the economics of water power in respect to these 2 main components, energy and capacity, and to give an outline of future possibilities for enhancing the economic value of water power.

Factors Controlling Choice of Hydro or Steam

Few electric systems in this country are supplied wholly by hydroelectric generation, chiefly because it has been economically advisable and often necessary to provide, by means of steam plants located near load centers, reserve generating capacity for use during periods of low water flow. There is no generally accepted ratio of hydroelectric to steam capacity for best economic results; the optimum proportion for any system is determined by the relative investment cost, fuel costs of steam energy, and characteristics of system load and water supply.

Fundamentally, the benefit derived from the 2 sources of supply comes from combining the low operating energy cost of water power with the low unit investment cost of steam; while the total investment to carry the system peak may be larger in a combined system than with steam alone, the excess investment is more than compensated by the

Fig. 1. Generator room of the Safe Harbor hydroelectric plant on the Susquehanna River, a large low-head run-of-river pondage plant

Each of the 36,000-kva generators is driven by an automatically adjustable blade Kaplan turbine

Full text of the first part of a paper "Economic Aspects of Water Power" (No. 32-128) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10–13, 1932.

low cost of energy derived from water power. The 2 sources of power should be regarded as supplementing rather than competing with each other. Quick-starting characteristics of hydroelectric units, namely, the ability to start them from standstill and synchronize them with the load in a small fraction of the time required for steam units, provides a high degree of standby readiness for emergencies. Hydroelectric units, especially of the low head type having short water passages, are well adapted to maintain system frequency. Water storage can be drawn upon to relieve the steam plants of the task of ironing out discrepancies in the forecasting of system load demands, to save banking extra boilers and generation by less efficient units, and to facilitate the advance scheduling of equipment for generation as well as for withdrawal from service for inspection and maintenance. Hydroelectric generators also are adapted to no-load operation as synchronous condensers for voltage regulation or power factor correction without consuming much energy or requiring elaborate precautions against overheating or rubbing as in steam units.

Firm Hydroelectric Capacity

The best method of operating a combined water power and steam system is generally to schedule the hydroelectric plants for maximum efficiency in periods of deficient water, and for maximum energy output in periods of plentiful water. Operation is simplified where water storage is available during low flow periods, hydroelectric capacity then can be held ready for instant use in case of emergency at associated steam plants. Water power always supplies a belt on the system load curve according to water availability such that the largest possible hydroelectric capacity is utilized; associated steam plants thus are operated at improved load factors in periods of deficient water.

That portion of the hydroelectric capacity which under certain assumed conditions (generally coincidence of highest system load demands with minimum flow) controlling the capacity investment for the system as a whole, will render the same capacity service in the upper portion of the system load curve that an alternative steam plant might perform, is called *firm hydroelectric capacity*. With large storage and favorable load conditions, the firm capacity of the first hydroelectric plant connected to a load system may be many times the minimum 24-hr power available. However, the minimum flow energy for a second hydroelectric plant feeding into the same load system will yield a relatively smaller firm capacity than the energy from the first plant, that is, the increment gain in firm hydroelectric capacity per unit of hydroelectric energy will decrease with an increase in the total amount of hydroelectric energy available.

Recent Developments Favoring Water Power

Certain factors of increasing advantage to hydroelectric development have made possible, and hold promise for still greater usefulness of, numerous hydroelectric projects that would not have been considered economically feasible during preceding years, notwithstanding the higher unit value of energy in those years. Among these factors is the present large size of electric utility systems in consequence of natural growth as well as of the interconnection of contiguous load areas. Almost without exception, new large scale hydroelectric developments are made by electric systems that supply either metropolitan load centers or a group of systems covering a regional territory.

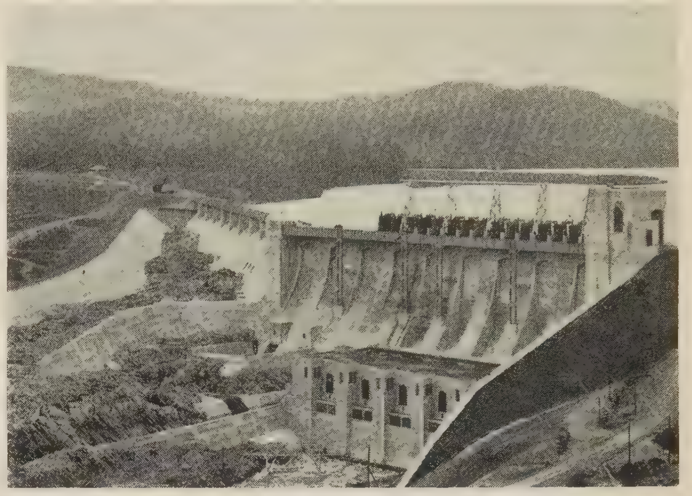

Fig. 2. Fifteen Mile Falls plant on the Connecticut River, a typical low-head storage plant

Shape of the peak of electric system loads is favorable for utilizing a large installed capacity in hydroelectric plant under minimum water conditions, which allows a large capacity value to be allotted to water power. Especially in the region along the Atlantic seaboard the sharp peaks of the various metropolitan load centers, although seasonal and of short duration, may occur simultaneously at the same hour and on the same day. This lack of assured diversity in load demand of interconnected systems, while unfavorable from the point of view of over-all power cost, gives storage-equipped hydroelectric plants an opportunity to utilize a greater portion of their installed capacities for firm peak service on the combined system.

Another feature of large utility system loads has been the annual increase in peak, which has been of such an amount that within a comparatively short time the entire capacity of new hydroelectric developments has become usable on the peak. At the same time the minimum system load is sufficient to absorb a large hydroelectric output when water is plentiful in run-of-river plants. Plants that can be developed beyond the continuous flow capacity at a low incremental cost can produce a great deal of low cost secondary energy.

Advances in the art of power transmission have made it possible to transmit large capacities over long distances at reasonable cost, with good voltage regulation and with low energy losses. In some instances step-up switching stations at the hydroelectric plants and step-down terminal stations of trans-

mission lines can be developed advantageously as integral parts of interconnection projects; thus large power systems that formerly functioned as separate units are tied together into a regional power system extending over a large area. In this manner a dual function is performed by the transmission and tie-in investment, especially on systems where 230 kv has been adopted as the standard transmission voltage. The high degree of service reliability of all types of equipment at this voltage has encouraged designing engineers to simplify their system layouts and to rely more on higher mechanical and electrical factors of safety in equipment than on a multiplicity of lines and reserve apparatus; this has a tendency to reduce investment cost or increase the service value of hydroelectric projects. Most recent operating experience with high voltage transmission lines embodying some advanced features of design, has been so satisfactory, that lightning proof operation of transmission lines is within the range of possibility at a not too distant future.

At the hydroelectric plant proper, several factors have contributed toward lowering the investment cost, aside from the lower price levels of structures and machinery. With construction plants laid out for low handling cost and rapid progress, and with careful engineering work applied to temporary structures, flood control, etc., the period of construction has been shortened; substantial amounts thereby are saved that formerly were expended on interest and other carrying charges during construction. Economies in the cost of financing are made possible by the sponsoring or underwriting of major enterprises through existing large utility systems, and few projects are undertaken now for which the market has not been secured in advance at least to the extent necessary to insure the interest on bonded indebtedness with a sizable margin of earnings.

It is possible now to get more capacity out of a given structural space, not only because of the increased size of units, but also because of the higher specific speed of turbine runners and improved design of water passages. Higher speed and improved design of machinery have lowered the cost of main turbine and generator equipment. Auxiliary apparatus has been simplified and its cost decreased. No appreciable improvement in best efficiency of runners has been recorded during the past decade, at the beginning of which peak efficiencies in excess of 90 per cent already had been reached; however, with the advent of the adjustable blade Kaplan turbine high efficiency can be secured in low head plants over a much wider range of loading, and the over-all efficiency of energy conversion for the plant as a whole can be raised noticeably over that of earlier installations. Testing of models no longer is confined to runners and draft tubes, to observations of efficiency and output, and to studies of the cavitation problem; but extends to every phase of the project from headwater down to the lower end of the tailrace channel. As a result of model tests, more economic designs of spillways, pier and apron sections, flood gates, etc., have been developed. Effective steps have been taken at the newer plants to guard against service interference by trash and ice.

Pumped Storage Plants

Pumped storage plants involving specially constructed high or low level storage reservoirs do not play so important a part in the power supply scheme of large systems in the United States as they do in Europe. Several such projects are under discussion, but only one major installation, a plant built in 1928 on the Rocky River, a small tributary of the Housatonic River in New England, is actually in service. The plant pumps from the Housatonic River to a reservoir of 68,000 cfs-days usable capacity on the Rocky River. The average yearly runoff of the Rocky River is 17,000 cfs-days.

While pumping is done mainly by off-peak steam power, the Rocky River plant provides in addition seasonal storage service to other plants located below on the Housatonic River. Installation of the 24,000-kw generating unit in the Rocky River plant and the pumped storage reservoir actually added 40,000 kw of yearly firm capacity to the electric system served by the plant. The efficiency of direct recovery by the Rocky River plant alone is approximately 60 per cent, but on account of the lower plants the over-all conversion economy derived from all plants is raised to nearly 80 per cent.

Dual Use Capacity Installations

This novel type of development is related functionally to pumped storage plants, being based upon the principle of converting low cost off-peak energy into high value peak capacity and energy. It employs the same unit as a turbine-generator and a motor-pump set, without, however, requiring a specially constructed high or low level storage reservoir, conduits or hydraulic control equipment. It is especially adapted to those plants where the increment cost of generating and transmitting capacity is lower than that of equivalent steam capacity and where a substantial overlapping of heads can be arranged readily. Runoff characteristics should be such that, depending on the efficiency of the conversion cycle, the duration of the low flow stage, during which conversion of off-peak energy into peak energy takes place, is not too great compared with the duration of the excess flow period, during which the dual use equipment produces energy for the system. These conditions are somewhat interrelated: In some instances a large saving in investment cost may more than compensate for the extra cost of energy in conversion losses during low flow exceeding the gain in output during high flow, notwithstanding the fact that on such a project the low flow days may outnumber greatly the high flow days.

Operating the generator in reverse direction as a motor offers no serious difficulties. However, the design of different types of turbines and hydraulic structures for dual use at synchronous speed and the possibilities of variable speed electrical and hydraulic equipment have yet been developed not to such a degree that this simplified regenerative cycle can be adapted readily to those water power projects where natural conditions of the power site are favorable.

A great deal has been published in the technical literature, especially in Europe, on the principles and applications of pumped storage predicated in each instance on the employment of 2 separate hydraulic motors, one for generation and the other for pumping, and in nearly all cases also on the use of a specially constructed high or low level reservoir. Employing a single hydraulic motor for dual use omitting specially constructed reservoirs introduce substantial economies in capital investment, but involve a sacrifice in conversion efficiency.

Perhaps in the search for optimum efficiency, we are inclined at times to throw aside as unworthy of further study, the suggestion that a process admittedly inferior from a point of view of efficiency may yet be superior from the point of view of over-all economy. The simplified method of hydroelectric regeneration has not been treated so far in the technical literature. As a proper evaluation of the possibilities of this process is of some importance on account of its effect on the economics of future hydroelectric developments, the principles underlying this method as well as some empirical results from laboratory and field tests will be described in greater detail in a later article including an analysis of those factors that will limit its field of application.

Analysis of Hydroelectric Power Costs

Cost of hydroelectric power may be regarded as consisting of 4 main components, namely:

1. Base cost of the development, which is more or less independent of the amount of installed generating capacity.
2. Cost of generating capacity, including low voltage switching equipment.
3. Transmission investment, including step-up transformers and other high voltage equipment at the power house.
4. Tie-in investment, such as step-down transformer and switching stations, underground cables, and other special equipment necessary for delivering hydroelectric power to a distribution system or to a high voltage network.

Until quite recently it had been customary to group the first two components into the single item—cost of power plant. This practise usually was adequate for the purpose when investigating the economics of existing plants. However, segregation into the 2 components, base cost and increment cost, is almost indispensable during the preliminary or project stage of a new development in order to determine the most economic size of the initial and ultimate installation and the part that it should play in the power supply scheme of a territory. The fact that such a differentiation exists, that the 2 components can be segregated readily and that their relative magnitudes as well as their values per unit capacity furnish a yardstick for comparing one project with another, is one of the characteristic economic features of hydroelectric plants as distinguished from steam plants; in the latter the first component, base cost, ceases to be an important factor after more than one generating unit is installed.

Cost of dam, property, flowage rights, construction equipment and temporary structures, relocation of bridges, highways, railroads, general site improvements, a certain minimum of tailrace excavation, auxiliary station equipment, all of which to some extent are independent of the amount of capacity installed, constitute the base cost. For many reasons this cost for almost identical hydraulic conditions of head, average discharge, and length of backwater, may show variations of several hundred per cent.

The second component comprises the cost of generating equipment, hydraulic as well as electrical, power house substructure and superstructure, low voltage switching and auxiliary equipment, intakes, control equipment, increment tailrace excavation, and related equipment. It sometimes is called the

Fig. 3. Rocky River plant of the Connecticut Light & Power Company at the junction of the Rocky and Housatonic rivers near New Milford, Conn., the only major pumped storage plant in the United States

The plant is situated on the Housatonic River, being connected to the storage reservoir on the Rocky River by a single penstock which serves both the 30,000-kva turbine-generator unit and 2 8,100-hp pumps; provision is made for a second penstock at the Y-connection just beyond the surge tank. What appears as a black line just above the dam is a boom to protect the dam from wave action. The circular tower at the left end of the dam contains the trash racks and intake gate to the penstock. For a description of the development see A.I.E.E. Trans., v. 47, 1928, p. 1,100–07

incremental cost of hydroelectric capacity. For similar hydraulic conditions this second component, expressed in dollars per kilowatt, is almost constant except for major fluctuations in price levels and for differences in accessibility of the power site. Even over a wide range of hydraulic conditions it rarely will deviate more than 25 per cent from the average, which is approximately $60 per kw.

Considering the approximate constancy of incremental cost and the great variation of base cost, a full answer to the question whether a hydroelectric plant is a high or low cost development, cannot be given unless total power plant costs are segregated into these 2 components. For purposes of illustration, the values used in Figs. 4 and 5 have been selected as representative averages for a low-head pondage-equipped run-of-river plant, located on the eastern slope of the Appalachian range.

During the project stage, when only estimated and not actual cost figures are available, this approximate division of cost may be obtained by plotting against kilowatts of installed capacity as abscissa the estimated cost for the minimum capacity (C_{min}) as well as for the maximum capacity(C_{max}) under consideration. The point of intersection of a straight line, drawn through these 2 points, with the axis of cost will give the approximate value of the base cost component. As certain structural provisions usually must be made initially to permit expansion to a larger ultimate capacity the actual cost of the minimum capacity installation (C_{min}) will be somewhat higher than the estimated cost of minimum capacity exclusive of these provisions for future expansion.

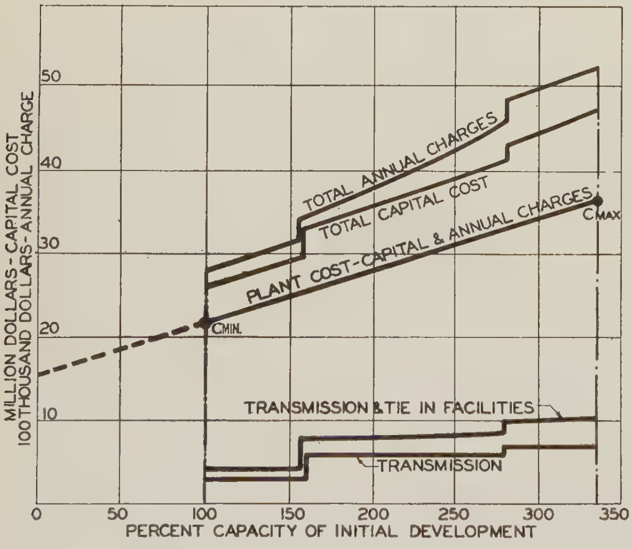

Fig. 4. Analysis of the cost of a hydroelectric project

The vertical scale in Fig. 4, representing capital cost, can be converted readily into a proportionate scale of annual charges, for the sum total of interest charges, taxes, depreciation, operation, maintenance, and other expenses, is approximately proportionate to investment. In Fig. 4 the over-all rate has been assumed at 10 per cent, based upon an average return of approximately 7 per cent on investment. Depending on the method of financing, this over-all rate may be reduced somewhat especially during the initial years.

The sum of the first 2 components represents the cost of the power plant proper, controlled largely by the hydraulic characteristics of head and discharge and by local conditions at the power house site and along the shores of the pond or reservoir. The other 2 components of cost, transmission and tie-in investments, are controlled by the geographic location of the plant in respect to its potential market, and by the opportunities of effecting a physical tie-in to existing lines or distribution networks at a minimum cost. Although bearing hardly any relation to plant costs, yet these 2 components must be fully considered as cost elements for hydroelectric power. It is not infrequent that a low cost and in every other way seemingly ideal project is uneconomic by reason of excessive transmission and tie-in cost. Conversely, certain other projects may be favored by short transmission distances to load centers, nearness of existing high voltage lines, and advantageous location of step-down stations in respect to city distribution systems.

In some special cases these 2 components of costs may become a credit rather than a charge. If, for example, a large power consuming industry is so close to the power site that it can be served economically at generating bus voltage, there will be a saving in transmission cost compared with supplying power to that industry from a more distant source; or if nearby railroad lines are electrified, there may be a distinct saving in tie-in expense not only because of the nearness of the electrified tracks, but also because where the railway operates from a 25-cycle single-phase system, lower speed single-phase generators can be used instead of the customary frequency converting equipment required in connection with 60-cycle steam power. These cases are exceptional rather than average; as a rule, the combined cost of transmission and tie-in investment will appear as a charge rather than a credit for hydroelectric power. Especially where long distances are involved, such as Boulder Dam or the St. Lawrence development, the cost of these 2 components may be equal to or exceed the increment cost per kilowatt of installed hydroelectric capacity. Development of 230-kv transmission has a tendency, where large amounts of power are involved, to reduce the transmission cost for a given distance, but to increase slightly the tie-in cost.

As extensions are made at the hydroelectric plant the cost of transmission will increase in sharp steps corresponding to the building of additional transmission lines, but the tie-in costs usually will grow at a gradual rate, corresponding to the step-by-step installation of additional underground cables and other tie-in equipment to keep pace with the increase in hydroelectric capacity. Annual charges for transmission and tie-in facilities will bear again a proportionate relation to the investment, but at a somewhat higher rate (12 to 15 per cent) than that used for the annual charges of the plant proper.

While it may appear academic to combine at an

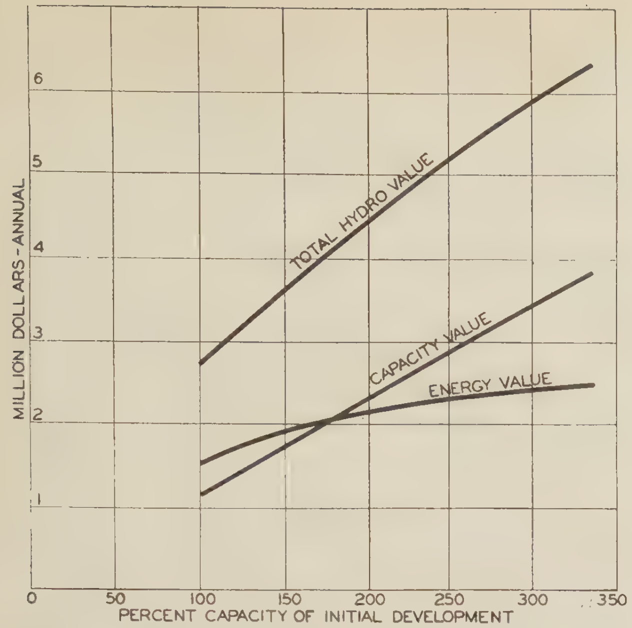

Fig. 5. Analysis of the value of a hydroelectric project

early stage of the project the estimated cost of the plant proper with the cost of transmission and tie-in facilities which are indirectly dependent upon marketing the power, yet a tentative forecast of these cost components is indispensable to a preliminary investigation of the economic justification of a project. Instead of adding these 2 components to the other costs of hydroelectric power, they could be subtracted from the composite value of the power, which is analyzed in the paragraphs that follow. This latter method, however, would not give as clear and convenient a graphic picture of the relationship of over-all cost and value.

Value of Hydroelectric Power

The generally accepted yardstick for evaluating hydroelectric power is the replacement cost of its 2 main components, capacity and energy, by the cheapest alternative source of supply—steam. Hydroelectric projects that have only a single potential market for their output, are more readily analyzed than those projects that have several possible outlets for power and the operation of which can be so coordinated with the operation of several steam plants that hydroelectric power renders the relatively most useful, and therefore the most valuable, service to the combined system.

Aside from the replacement value of water power as measured by the steam yardstick, a hydroelectric plant, by proper coordination of power house discharge, may add materially to the energy and capacity output of any plants located farther downstream. There are also several other collateral or contingent advantages of hydroelectric power which would be difficult to express in definite figures. Some of these features have been referred to in previous sections of this article dealing with the choice of water power or steam as a source of supply. For the purpose of this approximate analysis, however, all of these collateral features are omitted and evaluation of water power is confined to the 2 main components, capacity and energy.

It is evident that there can be credited toward the cost of hydroelectric capacity only an amount equal to the cost of equivalent steam capacity that would render a corresponding amount of firm peak service on a given system load, and that otherwise would have to be provided in the form of steam investment in order to insure adequate reserve capacity for the system. Strictly speaking, this definition would limit in the initial year the capacity value of a hydroelectric plant of any type to the annual increase in connected system load, or at the most, to the capacity of a single steam unit if the latter is larger than the anticipated increase in system load. This rather narrow definition gradually is giving way to the long range point of view, taking into account the average capacity value rendered over an extended period.

For a given amount of minimum flow energy, the amount of hydroelectric capacity that can render firm peak service to a system will increase gradually with the growth of system load, provided the load curve at least in its upper portion retains approximately the same shape. If additional load areas that previously supplied all of their requirements by steam can be tied in to a new hydroelectric plant the firm peak service rendered to the combined system will be increased materially. This is true provided, of course, that these new loads are similar in character to those originally served by the plant.

Capacity value per kilowatt comprises, in addition to the fixed charges—interest, depreciation, taxes, insurance, and some general expense—those items of steam plant operating costs that are more or less independent of the amount of power generated. This combined value varies somewhat in different localities. Aside from differences in price levels, it probably is more affected by the size of individual steam units than by any other single factor. Under

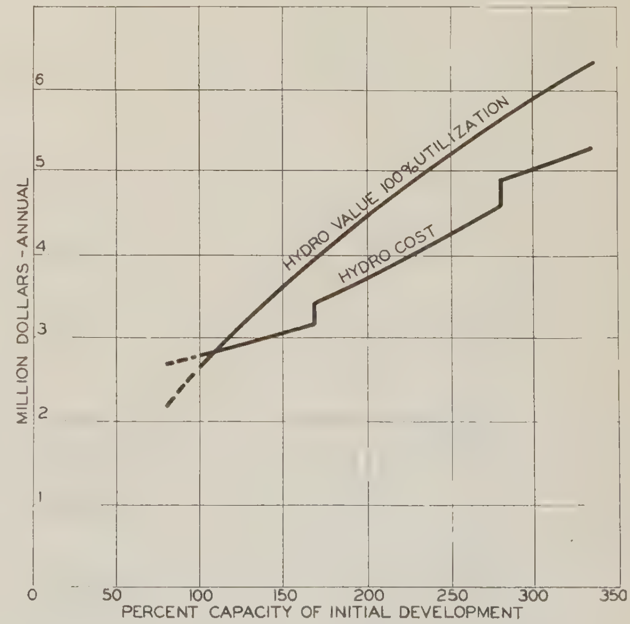

Fig. 6. Comparison of cost and value of a hydroelectric project

present conditions its lowest value is perhaps in the neighborhood of $10 per kw but in some instances exceeds $18 per kw for modern medium sized stations; the average is in the neighborhood of $13 which is the value used in Fig. 5.

The energy value per kwhr comprises, in addition to the cost of fuel and maintenance, only some minor items of operating supplies and labor. Depending mainly upon the price of fuel in the territory, upon the heat cycle of the station, and upon the relative size of boiler and turbine units, the energy value under present conditions may be assumed to vary (except for mine-mouth plants) from a minimum of around 2 mills per kwhr, or slightly less, to a maximum of around 3 mills, the average being perhaps 2.5 mills for unit capacities of 50,000 kw and higher. This latter value has been used for computing the total energy value of the hydroelectric project analyzed in Figs. 4 and 5, assuming full utilization of the water power available.

In order to approximate the effect of transmission losses, of capacity reductions by flood stage, drawdown of pond, etc., certain reductions have been applied to energy as well as to capacity. For less than full utilization of either installed capacity or available water power, the combined curve will drop below the values indicated, the amount of which reduction can be determined readily as a proportionate reduction of the respective component parts.

Composite curves of hydroelectric costs and values have been replotted in Fig. 6 to bring out more clearly certain trends frequently observed in connection with major hydroelectric projects serving a large interconnected load system supplied by water power and steam. During the initial years of operation, water power will compare less favorably with steam than during later years. However, a reasonable expectation is that a hydroelectric plant which has low incremental cost and not unduly high cost of transmission and tie-in facilities in the long run will yield a substantial margin of savings below the cost of steam. In addition, there will be several collateral advantages to its credit, which have been omitted in this graphic presentation.

Metal Deposition in Electric Arc Welding

Experimental work here reported indicates that liquid globules are the chief form of metal transfer in electric arc welding. A new method of high speed "recording" produces a metal record which can be compared directly with a corresponding oscillogram.

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METAL TRANSFER is one of the most important functions of the electric welding arc. Whether the metal deposited passes through the arc as vapor, as mist, or as globules larger than mist, long has been under discussion; as also has been the nature of the driving force of transfer, particularly in overhead welding where the counteracting force of gravity must be overcome.

Some students of this phenomenon have thought that the larger part of the metal is transferred as vapor generated at the tip of the wire electrode and condensed in the crater formed on the object welded. Others, pointing out the large amount of energy required to vaporize the metal at the tip of the electrode, have reached the conclusion that the principal transfer must occur as mist or globules of molten metal. Some have attributed the driving force to the evolution, within the melting tip of the electrode, of gas which results in a succession of tiny explosions discharges particles of the metal. Still others have explained the transfer as resulting from the forces of adhesion and surface tension between the molten metal on the electrode tip and that in the crater when the 2 liquids touch each other.

Another theory recently revived cites the "pinch effect" as accounting for the force necessary to separate the globules from the electrodes. (This subject is reported at length by F. Creedy and, with discussions thereon, recorded, on p. 556–66 of the A.I.E.E. Trans., June 1932.—*Ed.*) Finally, this last theory has been supplemented by discussion which suggests that the globule is propelled from the electrode by the forces resulting from the tremendous current density existing in the neck or filament of metal formed just as the globule is being separated from the electrode.

Other experimenters have found that whereas they were able to do overhead welding with ordinary steel wire, they were unable to do it with a wire of pure iron free from gas. This would seem to indicate that the combined action of "pinch effect" and surface tension, or "pinch effect" and vaporization of the

From, and presenting essential substance of, a paper presented at the Fall meeting of the American Welding Society, Buffalo, N. Y., Oct. 4, 1932.

pinched part of the conductor, is insufficient to transfer the metal against the force of gravitation without the help of the expulsive action of gas contained within the melting tip of the electrode.

All these experiments and theories emphasize the importance of the mechanism of metal transfer, and reveal the incomplete state of knowledge of its nature.

A partly successful attempt to record by high speed continuous photography the forms in which metal is transferred through the arc has shown that some metal is transferred as globules and some as threads. Instantaneous conditions revealed are shown in Figs. 1 and 2. This method, of course, would not show the metal which might be transferred as mist or as vapor.

A New Method of Study Disclosed

In the welding laboratory of Lehigh University has been developed a new and direct method of investigating this subject of metal transfer, a method which records *all* of the possible forms in which metal is transferred through the arc. The principal feature of the method involves the moving of a highly polished metallic strip under the arc at a speed sufficiently high to enable each successive deposit of metal to be made on the strip distinctly separated from the others. The metal strip, or metallic mirror, thus gives a continuous and chronological record of the character of the deposit, and each form retains its identity and is easily recognized, whereas in ordinary welding the globules, mist, and vapor merge in the molten crater and lose their identity at once.

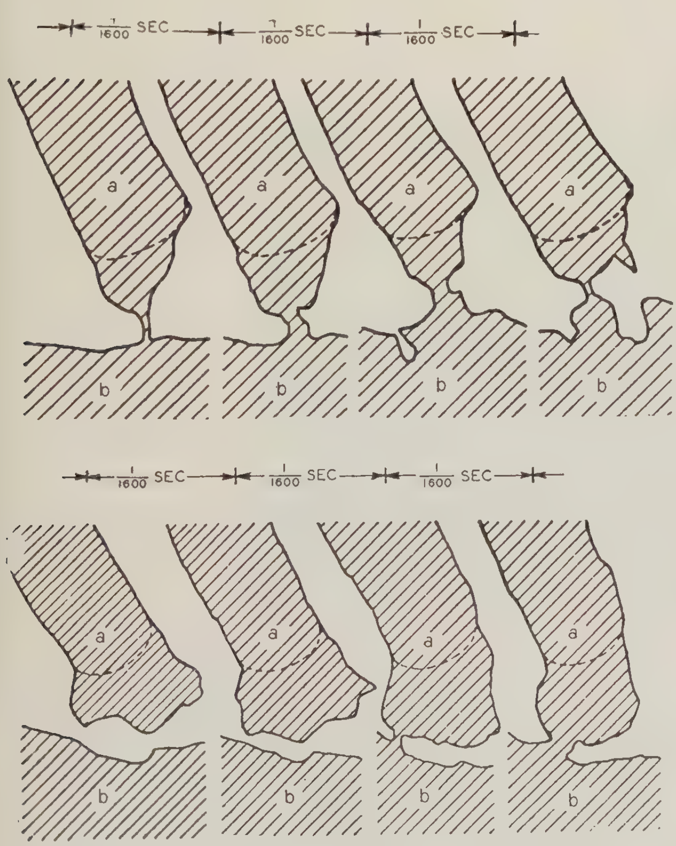

Fig. 1. Instantaneous conditions in the transfer of metal by means of the electric arc; above, thread shaped transfer; below, mushroom shaped globules

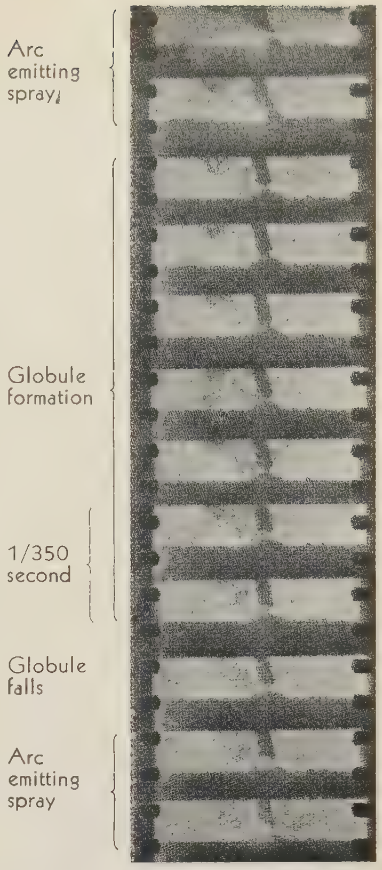

Fig. 2. Thun's high speed photography showing a cycle in electric deposition

In the Lehigh experiment a polished strip of mild steel 4 x 36 x $^1/_4$-in. in dimensions was run through an automatic welding machine at a rate of speed in excess of 100 in. per min, using a $^5/_{32}$-in. mild steel wire, a current of 150 amp, and somewhat more than 20 volts across the arc. The energy was supplied from a standard arc welding motor generator set. Results as shown in Fig. 3, where it may be noted that the flattened globules ranging between $^1/_{16}$ and $^3/_{16}$ in. in diameter at the base, clearly are shown to form the major portion of the deposit. Many of these show a gas cavity caused by the escape of dissolved gas as solidification took place. Under the conditions of this experiment, any vapor was oxidized before deposition and appeared on the strip as a red powder. The particles of spray also were oxidized, although probably only to Fe_3O_4, as a result in the decrease of surface-to-volume ratio in the larger spheres. To condense these two forms of deposition unoxidized the air about the arc would have to be replaced by an inert gas such as argon. Examination indicates that, in this case, the amount of material deposited in these forms was considerably less than 10 per cent of the total deposit, and that the chief form of transfer was as liquid globules.

Conditions involved in this test differ, of course, in some respects from those of ordinary welding. For instance, the heating of the strip under the rapidly advancing arc is insufficient to cause crater formation. Surface fusion does take place, however, beneath each globule, even at this speed, as examination shows the globules are tightly welded to the plate and resist removal by the chisel. Therefore, the temperature of the strip under the arc has been at least 1,500 deg C (the melting point of steel). A temperature considerably higher than this (probably 2,450 deg C, the boiling point of iron) exists at the crater in normal welding and therefore more heat is radiated from the crater to the wire tip, but the amount of heat so radiated to the globule on the tip

of the electrode, as calculated by the Stefan Boltzman law, seems to be less than 10 per cent. This would not be sufficient to vaporize any considerable proportion of the globule before it left the wire, and thus would not change appreciably the proportion deposited as globules. The conditions of this test thus are at least enough like those of ordinary practise to render them suitable for comparative investigation of the basic phenomena of deposition.

Oscillographic records of the instantaneous values of current and voltage of the arc accompanying each series of depositions were taken on a 6-ft film, a section of which is reproduced in Fig. 3 where the deposit accompanying each current peak on the film is shown below its own peak. The accuracy with which the oscillogram records the operation of the depositing mechanism is striking. The size of the current disturbance on the film corresponds quite well with the size of the globule deposited on the strip. For instance, the overlapping globules at the extreme right correspond to the group of current peaks on the film above it, and the same correspondence holds for the double globule near the center of the series. The tiny globules of spray seemed to bridge the arc sufficiently to give a voltage "zero," although the time was too short for appreciable growth of current. This voltage zero indicates that the deposition was not entirely a spraying process even for these tiny globules. The same momentary voltage zeros appear in several other places where spray is found.

The globule next to the left of the sprayed group (in the direction of motion) illustrates the simplest case, a single globule and a single current peak and voltage valley. Likewise, the next to the left shows a double globule and double peak, but its neighbor (third from left) and also the second one from the left, both show more peaks than globules, due perhaps to complete merging of the globules before solidification.

It may be interesting to note that the largest peak of a group is nearly always the first one, possibly indicating the transfer of accumulated liquid at the tip of the electrode. Also, one notes that between the peaks of a group the voltage rises to full arc voltage, with a very short overshoot of voltage above normal, whereas the current in the valleys between peaks does not drop fast enough to reach the normal current value in the short interval. The ordinary ammeter and voltmeter used in welding show, of course, only the average current and voltage, and do not show these rapid fluctuations.

In general, the correspondence between metal deposition and oscillographic record is surprisingly accurate. Eleven other complete strings of globules with oscillograms to accompany them were made, using a variety of electrodes, currents, and speeds, each with the general results the same as described.

Conclusions

These experiments indicate that liquid globules are the chief form of metal transfer, although there is some metal transfer as vapor and mist. A close correspondence is seen between the individual types of deposit and the individual features of the current and voltage waves on the corresponding oscillogram. The oscillogram would seem to be a trustworthy indicator of the depositing mechanism.

This method, revealing as it does the mode of metal deposition, offers also a means for testing and comparing the depositing performance or so-called "weldability" of various types of electrodes. The results of tests of this kind may be interpreted, moreover, both for hand and for automatic welding.

These results are for "bare," or very lightly coated, electrodes. The modern heavily coated electrode, because of its chemical protection to the metal in the arc, can and does use a longer arc length, in fact, so long that the globules are unable to bridge the arc and to cause the current peaks and voltage zeros of "short arc" welding. Globules are believed, however, to be the chief form of transfer, also when the longer arc and coated electrode are used. This question could readily be decided by the use of the method described in this paper, using heavily coated electrodes.

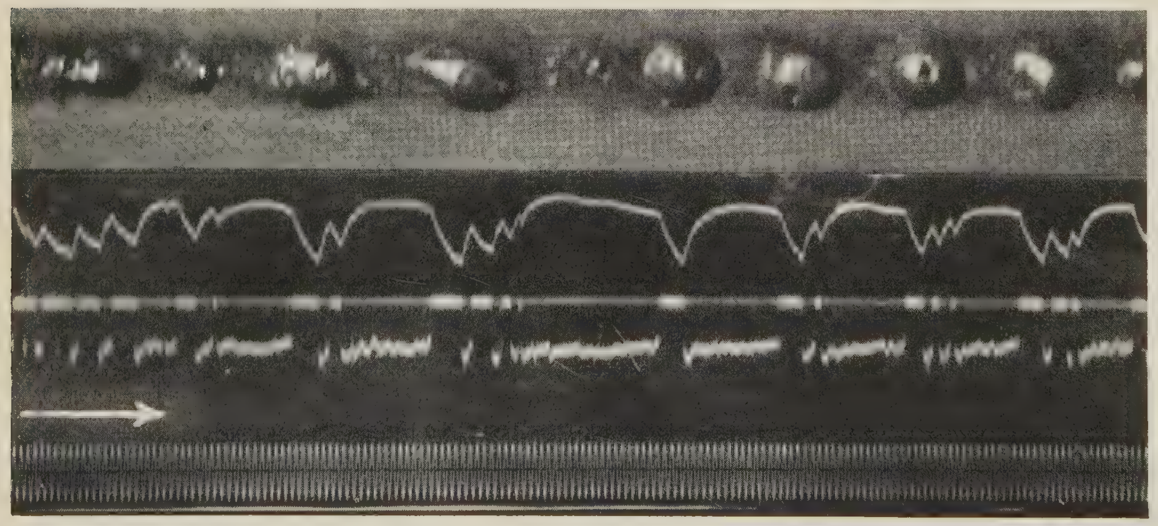

Fig. 3. Composite reproduction showing a section of the high speed metal "record" of actual deposition, and the relation of the various deposits to the corresponding oscillogram

Synchronous Motors in Rolling Mill Service

Improvements in the synchronous motor and its control, together with a growing recognition of its favorable first cost and operating characteristics, have resulted in its rapidly increasing application to constant speed main-rolls in metal-rolling mills, both steel and non-ferrous. A brief review of the present status of such applications, and some important controlling factors are given here.

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AT THE BEGINNING of 1932 there were 161 synchronous motors totaling 231,950 hp driving main-rolls in steel mills and in copper, and brass, and other non-ferrous mills. This amount of horsepower is small compared to the total in use on metal-rolling mills, nevertheless it represents the largest part of the horsepower in constant speed motors installed since synchronous motors have been developed for main-roll drives. The types of main-roll drives to which synchronous motors are applied and the number of units and horsepower installed are shown in Table I.

These units range in speed from 900 to 62 rpm; about $^1/_5$ operate at 25 cycles, the remainder at 60 cycles; approximately $^1/_3$ are direct connected and $^2/_3$ are geared to their mills; voltages range from 220 to 11,000 inclusive.

Requirements and Scope of Application

In the field of constant speed rolling mill drives, the only apparent limitation to the use of synchronous motors is on those mills having heavy passes of short duration where it is practise to interpose fly-wheels between the load and the line. However, with the present large and growing capacity of power systems supplying most rolling mills, the need of protecting the line from short-time high-peak loads becomes of decreasing importance and the elimination of flywheels is a desired step toward greater drive simplicity. Several synchronous motors now are applied successfully to main-rolls, such as plate mills, where motors with flywheels formerly were considered essential.

On large reversing mills, synchronous motors must be excluded from consideration because frequent and rapid reversal is one of the important requirements. On certain smaller mills, however, where relatively slower reversal and constant speed rolling are satisfactory, synchronous motors offer possibilities. One continuous-reversing synchronous motor now is in use driving a copper break-down mill.

The torque requirements for various types of main-rolls are given in Table II. Except for cold-roll mills, the starting and pull-in torque requirements under normal starting conditions are comparatively light, 50 per cent of the full load torque of the motor usually being ample. Emergencies, however, may require the mill to be reversed or jockeyed under load. Hence, starting and reversing torques ranging from 85 to 100 per cent must be available, secured by applying a higher percentage of full voltage, or full voltage to the motor in starting. Cold-roll mills, because of the very high friction load, require high starting and pull-in torques. The pull-out torque requirements will be determined, of course, by the type of load imposed by the particular mill, with the highest values in general for those mills where rolling is intermittent and the passes are short.

Rolling mills, although similar in the main features of their construction and operation, nevertheless vary considerably in their individual load characteristics and motor requirements. In Table II the approximate torque requirements for specific mills have been set up. This tabulation also presents some approximate data on motor ratings and the load characteristics of mills which afford opportunity for application of synchronous motors. Additional comments on the groups of mills shown in Table II are given in the notes appended to the table. By graphical kilowatt charts Fig. 3 depicts the important types of rolling loads encountered.

Motor Characteristics

Values of starting and pull-in torques available in synchronous motors of normal design vary considerably, depending upon the horsepower, speed

Table I—Applications of Synchronous Motors to Main-Roll Drives

Mill	Units	Hp	Avg Hp
Billet and bar mills	21	74,750	3,500
Tube piercing mills	20	41,300	2,000
Copper and brass mills	47	25,450	550
Rod mills	10	21,850	2,200
Tube rolling mills	8	11,600	1,400
Skelp mills	2	10,500	5,000
Hot strip mills	11	14,950	1,350
Merchant mills	11	9,900	900
Tube reeling and sinking mills	9	4,250	450
Structural mills	1	3,000	3,000
Tinplate mills	2	3,000	1,500
Cold-roll sheet mills	5	2,600	500
Rail rerolling mills	3	1,800	600
Cold-roll strip mills	2	1,000	500
Plate mills	1	1,000	1,000

Prepared especially for Electrical Engineering. *Not published in pamphlet form.*

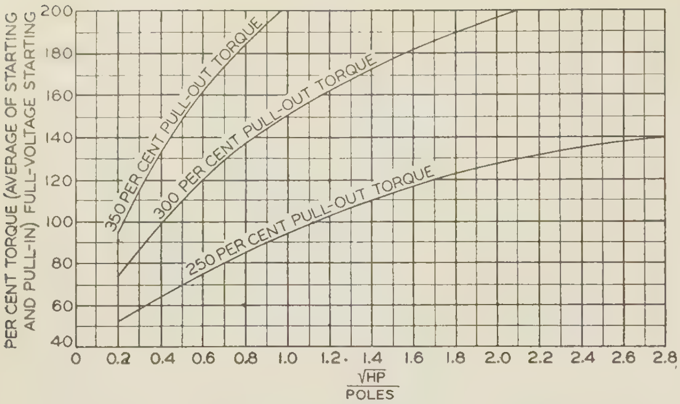

Fig. 1. Approximate relationship of starting and pull-in torque to motor horsepower, speed, and pull-out torque ratings for 60-cycle synchronous motors operating at 0.8 power factor and at speeds of 450 rpm or lower

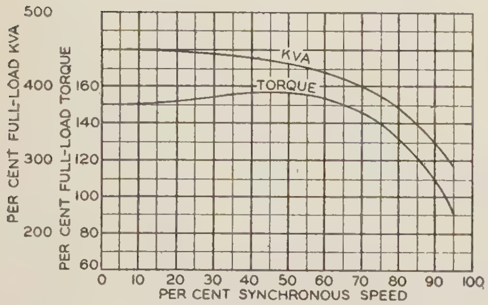

Fig. 2. Starting torque and kva curves for 3,000-hp, 450-rpm, 60-cycle synchronous motors operating at 0.8 power factor (calculated values)

rating, and pull-out torque for which any individual motor is designed. For purposes of illustration, the relations for motors of 0.8 power factor are shown approximately by the empirical curves of Fig. 1. These curves are for 60 cycles, and speeds of 450 rpm and lower. For 25-cycle motors the approximate relationship of starting and pull-in torque to motor horsepower, speed, and pull-out rating, can be derived from Fig. 1, for 0.8 power factor, by multiplying the 25-cycle motor horsepower by 2.4 to locate the desired point on the abscissa.

As illustrated by Fig. 1, an average of starting and pull-in torque in excess of 100 per cent is available inherently over a wide range of horsepowers and speeds, especially for higher values of pull-out torque. For low 60-cycle speeds, where full-load starting torques are not inherent in a normal design, they can be secured by increasing or changing the proportions of active material in the motor. Moreover in all cases, considerable latitude exists in the design of the induction-motor characteristics of the synchronous motor, so that individual values of starting torque and pull-in torque can be varied from the average to provide a torque curve most suitable to meet the requirements of main-roll drives. Pull-out torque requirements for main-roll drive can be secured more easily and less expensively in synchronous motors designed for operation at 0.8 power factor than in those designed for operation at unity power factor. From the standpoint of pull-out torque, therefore, motors operating at 0.8 power factor are preferable.

"Field-forcing" for increasing the field excitation to values above nominal to provide higher pull-out torque during the periods of peak loads, has interesting possibilities in providing for more economical applications on mills with high, but relatively infrequent peak loads. At present, so far as is known, its use is limited because of limitations in the quickness of response to sudden load increases. It is

10-stand 18-in. billet mill reducing 7 x 6 in. blooms to 2 x 2-in. billets. 5,000-hp 514-rpm motor

8-stand tinplate mill. 2,000-hp 300-rpm synchronous motor

10-stand cold-roll sheet mill. 500-hp 514-rpm motor

Seamless tube mill rolling pipe of approximately 10-in. diameter. 1,500-hp 86-rpm motor

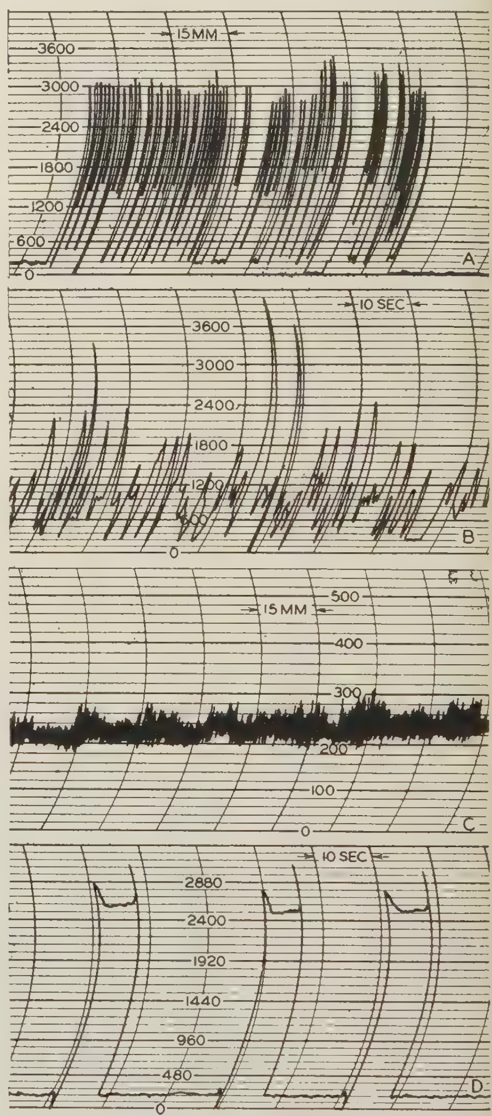

Fig. 3. Kilowatt charts showing nature of power demand met by various synchronous motors

applicable now to drives where increase in load is comparatively slow, or where the load increase can be anticipated either by the mill operator or by trip switches actuated by the metal entering the mill.

Under normal conditions of starting, except for cold-roll drives, the torques required to break the mill from rest and accelerate it usually are available with a power inrush not exceeding 175 per cent of the full load kva of the synchronous motor, secured by using one of the various methods of reduced-kva starting. For emergency starting and reversing, where starting torques higher than normal are necessary, the power inrush, of course, will be larger.

The kva starting demand of a synchronous motor, particularly in the larger mills, has become a factor of less critical importance than formerly. As a result, starting at full voltage, with attendant high kva inrush, can be tolerated in many instances to simplify both the starting operation and the starting equipment.

Starting characteristics of a 3,000-hp, 450-rpm, 0.8-power-factor, 60-cycle, main-roll synchronous motor are shown in Fig. 2. A starting torque of 150 per cent, with a starting kva of 450 per cent, is obtained with full-voltage starting. However, a starting torque of 50 per cent normally is ample for starting the mill and with this torque the starting kva is but 150 per cent of full load kva.

In the application of a synchronous motor to a main-roll drive, the inherent characteristics of the motor are such that several factors each must be considered individually. Although in this article an attempt has been made to set forth the general requirements, they should not be considered as ready-made rules which can simply be lifted out and used; good application engineering, with due recognition of the motor's shortcomings, is required at all times. In every case the motor must be designed and built with quite an exact advance knowledge of the mill requirements, necessitating close cooperation between engineers of the mill and of the motor manufacturer.

Notes on Table II

1. Types of mills listed are those which afford opportunity for synchronous motor drive, and in general they are the types most frequently used.

2. Motor horsepower and speed limits are approximate.

3. See kilowatt charts of Fig. 3 for graphical depiction of load characteristics for some of these mills.

4. Torques are given as a percentage of the full load torque of the motor, and are based on the average horsepower required for the type of mill. Increase or decrease in horsepower will modify the torque percentages. Torques shown above apply regardless of type of starting used.

5. Lower values of starting torque shown usually are ample to start the mill unloaded, but the higher torques shown must be available.

6. Both 3-high, and continuous billet and bar mills offer suitable and advantageous applications for synchronous motor drives; many such mills now are so driven. Because of the relatively limited, large sections rolled by these mills, speed flexibility usually is not of primary importance, and a constant speed drive is satisfactory.

7. For the roughing and intermediate stands of skelp, hot-strip, merchant, and rod mills, where the metal section is large and the rolling speed relatively slow, a constant speed drive generally is satisfactory, and synchronous motors are applied to advantage. For the finishing stands, where the metal section becomes light, and elongation is rapid, adjustable speed motors usually are necessary.

8. Plate mills constitute somewhat of a border line case for synchronous motor application because of the high, short peaks encountered. Conditions permitting, the synchronous motor should prove an advantageous drive, particularly because its use would eliminate speed variation as a deterrent factor in controlling uniformity of gage in rolling. For the roughing and shaping stands used in rolling rails and structural shapes, synchronous motor drive is subject to the limitations imposed by high, relatively short load peaks. For the finishing stands, however, where constant speed is satisfactory, synchronous motor drive is quite suitable.

9. The severe loads imposed by sheet and tinplate mills (of the non-continuous type) are made up of heavy impacts of short duration while the sheet-bars are being broken down, and heavy drags of longer duration when the sheets are being finish-rolled. The largely unrelated operation of the various mill stands results in irregular loads wherein the ratio of average horsepower demand to peak demand may be quite high. Synchronous motors show attractive possibilities of effecting substantial economies and improvements in production when applied to sheet and tinplate mills to replace present induction motors. The constant rolling speed afforded by the synchronous motor is of particular importance in insuring greater uniformity of gage in rolling thin sheets, and in eliminating variable speed as a factor in controlling mill production.

10. Cold-roll sheet mills also provide an attractive application for synchronous motor drives. The high friction load, together with the diversity of operation incident to the use of a single motor to drive several individually fed mill-stands, results in regular load and high load factor. High load factor enhances the economies of the high efficiency operation of the synchronous motor.

11. The load characteristics imposed by mills for making seamless tubes are somewhat alike. As the metal enters the mill, the load rises at once to its full value, remains almost constant at full value for the duration of the pass, then drops back immediately to no-load value. These passes vary in length from approximately 5 to 20 sec and are repeated from 2 to 4 times per minute. Except in the case of certain expanding mills and some reeling mills, a single

Table II—General Mill Characteristics and Torque Data for Synchronous Motors Applied to Main-Rolls

Application	Types of Mills[1]	Motor Horsepower[2]	Motor Speed[2]	Connection to Mill	Load Characteristics[3]	Torques[4] (per cent) Starting[5]	Pull-In	Pull-Out
Steel Rolling Mills								
Billet and bar mills[6]	Continuous or three-high	1,000 to 7,000	80 to 600	Direct drive, single reduction gear, or tandam gear set	Continuous mills: varying load, moderate peaks; Three-high mills: intermittent load, approx. 3 to 15 sec duration; high peaks	50 to 100	40	250 to 350
Skelp,[7] hot strip, merchant, and rod mills	Continuous	1,000 to 7,000	80 to 600	Direct drive, single reduction gear, or tandem gear set	Varying load, moderate peaks	50 to 100	40	225 to 300
Plate,[8] rail, and structural mills	Three-high	1,000 to 7,000	80 to 600	Direct drive, or single reduction gear	Intermittent loads, approx. 1 to 15 sec duration; high peaks	50 to 100	40	250 to 350
Sheet and tinplate mills[9]	Two-high trains	1,000 to 3,000	240 to 450	Single reduction gear	Continuous, irregular load, frequent high peaks	50 to 100	40	300 to 450
Cold-roll sheet mills[10]	Two-high trains	500 to 750	240 to 450	Single reduction gear	Continuous, regular load	150 to 200	100 to 150	250
Seamless tube piercing mill	Mannesmann or Stiefel	1,000 to 5,000	150 to 250	Direct drive, or single reduction gear	Intermittent loads, approx. 6 to 30 sec duration; high peaks. On rolling mills load duration may not be more than 3 to 4 sec.	50 to 100	40	250 to 350
Rolling mills	Two-high	1,000 to 2,000	62 to 83	Direct drive				
Reeling, sizing, and sinking mills	Two-high	350 to 600	450 to 600	Single reduction gear	Intermittent loads, approx. 6 to 30 sec duration; peaks moderate		...	250 to 300
Copper, Brass, and Other Non-Ferrous Mills								
Breakdown mills[12]	Two- or three-high	300 to 1,500	250 to 450	Single reduction gear	Intermittent loads, approx. 1 to 15 sec duration; peaks moderate	50 to 100	40	250
Finishing mills	Two- or three-high	250 to 600	250 to 450	Single reduction gear	Intermittent loads, approx. 5 to 15 sec duration; peaks moderate	50 to 100	40	250

speed drive is sufficient and the absolutely constant speed provided by the synchronous motor even at high overloads is a factor of considerable importance in making the tube. Also, the first cost and the high power factor and high efficiency at the comparatively slow speeds of these mills have caused the synchronous motor to be used widely for seamless tube mill drive.

12. Synchronous motors have been quite widely applied to non-ferrous breakdown and finishing mills. The power factor correction obtained for synchronous motors is of considerable importance in some plants, offsetting the low power factor characteristics of the induction furnaces used for melting.

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Thermal Transients and Oil Demands in Cables

Simplified solutions now may be obtained for the thermal transients and oil demands in power cables, due to load variations of any complexity whatever. Mathematical and graphical aids have been developed which greatly reduce the time and labor required for numerical work, and the theory has been verified by measurements on actual cables of the ordinary and oil filled types.

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SINCE underground power cables almost always operate under variable loading, it is desirable to be able to establish their allowable carrying capacities on the basis of variable loading, rather than on the basis of some equivalent steady state loading, as is the present practise. For this purpose it is most useful to know what temperature variations will occur at any point in the cable at any time due to an abrupt change from one constant load to another. Any load curve then can be handled with sufficient accuracy by breaking it up into a series of rectangular steps, and adding with proper time intervals the successive thermal transients.

The fundamental equations were developed several years ago, but the numerical solution was too complicated and laborious to be of general practical value. A simplified method is presented here, which employs calculating charts and other devices permitting complete exact solutions to be obtained in less than 20 per cent of the time formerly required. In addition to temperature transients due to abrupt load changes, precise simplified solutions for the following related phenomena are given:

1. Oil demands due to abrupt load changes in oil filled cables.

2. Temperature transients and oil demands due to load variations of any kind, whether abrupt or otherwise.

Although the methods described in this paper were developed for problems of single conductor

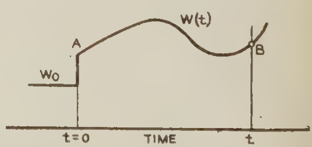
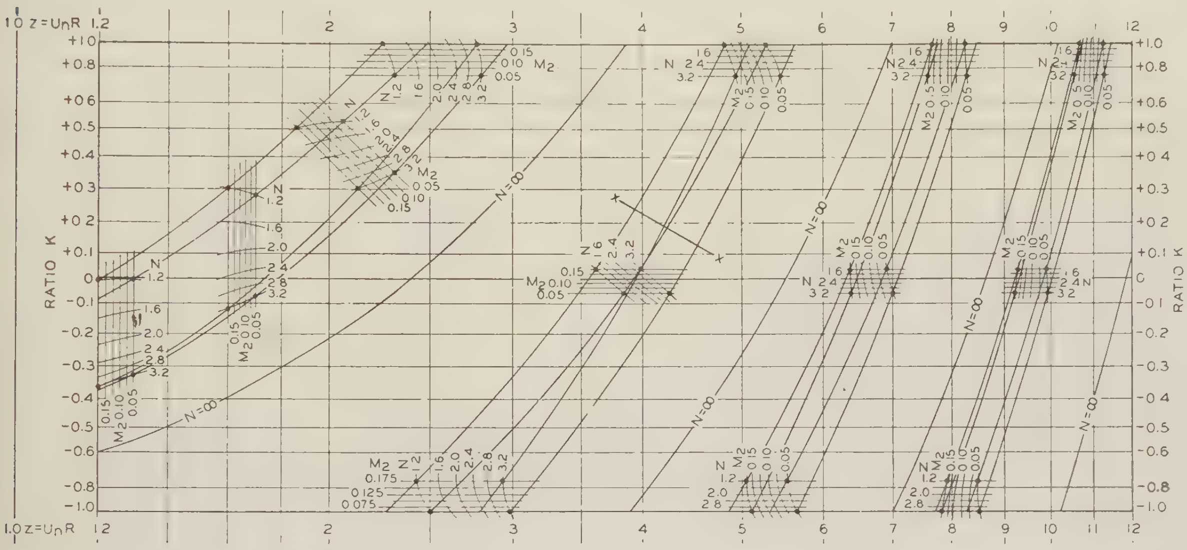


Fig. 1. (Left) Rectangular load change
Fig. 2. (Right) General load variation

cables, they can also be applied directly to 3-conductor cables, using a per phase basis (*e.g.*, sheath thermal resistance = $3E$, etc.). For 3-conductor oil filled shielded cable with round conductors, the accuracy will be excellent. If the conductors are sector-shaped, good accuracy may be obtained by using the equivalent round conductors. For ordinary 3-conductor cable with solid fillers and no shielding, the accuracy will be only fair.

Based upon "Thermal Transients and Oil Demands in Cables" (No. 32-127) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., October 10–13, 1932.



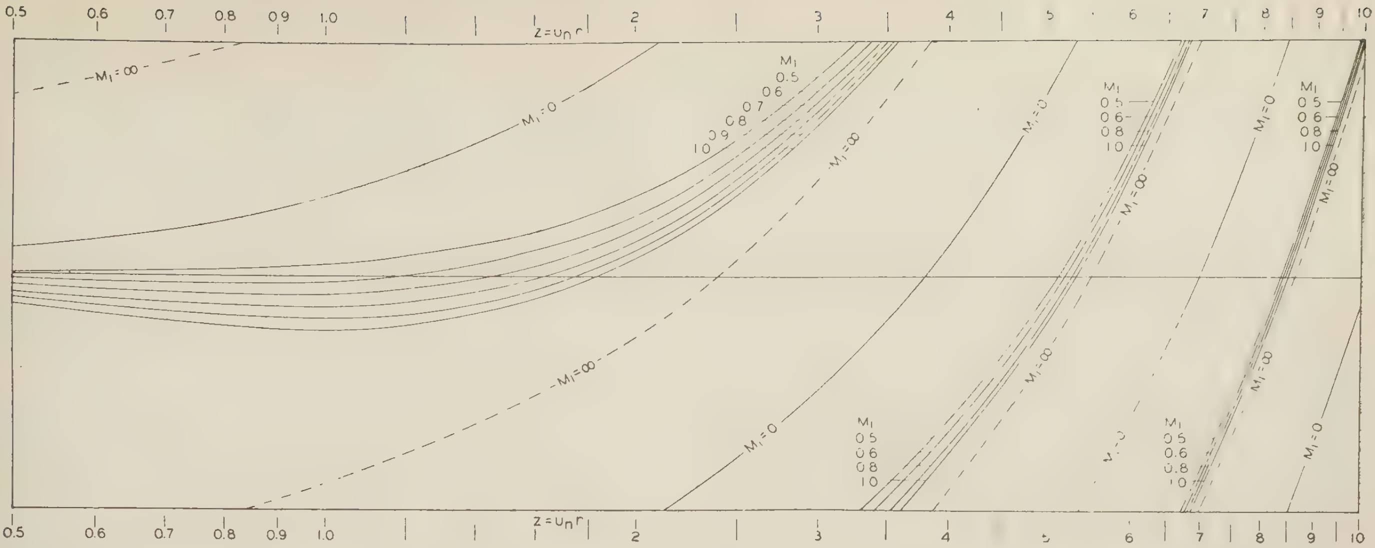


Chart 1 (Above)

Chart 2 (Left)

Solution for Abrupt Load Change

For any abrupt load change such as illustrated in Fig. 1 the equation for the temperature at any point x in the cable at any time is:

$$T = \sum^{n} e^{-\lambda_n t} C_n F_o(u_n x, K_n) + \frac{W_c''p}{2\pi} \log \frac{R}{x} + \frac{W_i''p}{4\pi \log \frac{R}{r}} \left(\log \frac{R}{x}\right)\left(\log \frac{Rx}{r^2}\right) + (W_c'' + W_i'' + W_s'') E + T_o \tag{1}$$

where $\lambda_n = u_n^2/pq$

(For notation see List of Symbols)

For conductor temperature, x is replaced by r, and for sheath temperature by R. The component oil demands contributed by shrinkage of the conductor, sheath, and insulation are, respectively:

$$a_1 = \frac{Cc}{pq} \sum^{n} u_n^2 e^{-\lambda_n t} C_n F_o(u_n r, K_n) \tag{2}$$

$$a_2 = \frac{Vv}{pq} \sum^{n} u_n^2 e^{-\lambda_n t} C_n F_o(u_n R, K_n) \tag{3}$$

$$a_3 = \frac{2\pi\epsilon}{pq} \sum^{n} e^{-\lambda_n t} C_n \left[F_1(u_n R, K_n) - F_1(u_n r, K_n)\right] \tag{4}$$

and the total oil demand is:

$$a = (a_1 - a_2 + a_3)$$

The values of u_n and K_n are obtained from n successive intersections (3 are generally sufficient) of the curves of Charts 1 and 2, which are entered

Instructions for Using Charts 1 and 2

1. Lay Chart 2 over Chart 1 so that the Z axes coincide, and Z = R/r on Chart 2 coincides with Z = 1 on Chart 1.
2. Interpolate on Chart 1 the sequence of curves for M_1 and interpolate on Chart 2 the sequence of curves for M_2, N.
3. Note the points where intersections occur between the interpolated curves of Charts 1 and 2. Three intersections are sufficient.
4. For the n points of intersection, read off K_n from the vertical scale. Also read off Ru_n and ru_n from the horizontal scales of Charts 2 and 1, respectively, starting at the left.

Note: In printed copy where Chart 2 is not transparent or removal permitted, it is convenient to trace the z axis, the interpolated P curve for desired value of M_1 and sufficient identifying abscissas z from Chart 1, on transparent paper, and to lay this tracing over Chart 2 with proper horizontal shift R/r (to the right), after which intersections may be found as already described.

Table I—Properties of Cable Materials

Material	Specific Gravity	Weight lb/cu in.	Joules/cu cm/°C	Joules/cu in./°C	Joules/lb/°C	Thermal Resistivity °C/watt/cu cm
Water	1.00	0.0361	4.18	68.6	1900	171
Copper	8.95	0.3230	3.44	56.4	175	0.285
Lead	11.37	0.4110	1.43	23.4	57	2.990
Transformer oil	0.90	0.0325	1.90	31.1	957	611
Dry paper	1.41	0.0508	2.26	37.1	730	770
Oil filled insulation	1.15	0.0415	2.10	34.5	832	550

The weight of copper conductor is 3.15 lb and its thermal capacity 551 joules per deg C per circular-inch foot, as ordinarily stranded and cabled.
The weight of lead sheath is 15.5 Dd lb and its thermal capacity is 883 Dd joules per deg C per ft, where D and d are the average diameter and thickness in inches.

with values of $M_1 = \frac{Q_1}{2\pi q r^2}$, $M_2 = \frac{Q_2}{2\pi q R^2}$, $N = \frac{p}{2\pi E}$, and $\frac{R}{r}$. The functions $F_o(u_n x, K_n)$ are obtained from Chart 3. The functions $F_1(u_n x, K_n)$ are obtained from Chart 4. Values of C_n are obtained from the following equation:

$$\overset{n}{\Sigma} - C_n F_o(u_n x, K_n) = \Delta W_c \frac{p}{2\pi} \log \frac{R}{x} + \Delta W_i \frac{p \left(\log \frac{R}{x}\right)\left(\log \frac{Rx}{r^2}\right)}{4\pi \log \frac{R}{r}} + (\Delta W_c + \Delta W_i + \Delta W_s)E$$

by evaluating all terms except C_n for n different values of x, and solving the resulting simultaneous equations. Values of C_n should be calculated for unit change in copper loss, dielectric loss, and sheath loss separately. Eq 1, 2, 3, and 4 will then yield "unit" transients. These need be calculated only once for a given cable, since for any particular problem the unit transients can be proportioned and added together in any ratio and combination desired, which is the work of but a few minutes. All quantities, such as p, q, R, W_c, c, etc., in the expressions for temperature and oil flow transients are readily obtained from Table I, or by well known methods which require no explanation.

The oil flows obtained from eq 2, 3, and 4 will be slightly in error for the first few moments of the transient, because only a few terms in the infinite series are used in obtaining numerical values, and the neglected terms are appreciable when t is very small. The following correct expressions should be used for the initial instant ($t = 0$):

$$a_1 = -\Delta W_c \frac{Cc}{Q_1} \quad a_2 = -\Delta W_s \frac{Vv}{Q_2} \quad a_3 = -\Delta W_i \frac{\epsilon}{q}$$

Solution for General Loading

The rectangular solution is readily generalized, almost by inspection, through a well known application of the superposition principle. For the entirely general load curve of Fig. 2, the general solution for temperature at any point x is:

$$T = \overset{n}{\Sigma} C_n F_o(u_n x, K_n) L_n(W, t) + (W_c)_t \frac{p}{2\pi} \log \frac{R}{x} + (W_i)_t \frac{p}{4\pi \log \frac{R}{r}} \left(\log \frac{R}{x}\right)\left(\log \frac{Rx}{r^2}\right) + E(W_c + W_i + W_s)_t + T_o \quad (5)$$

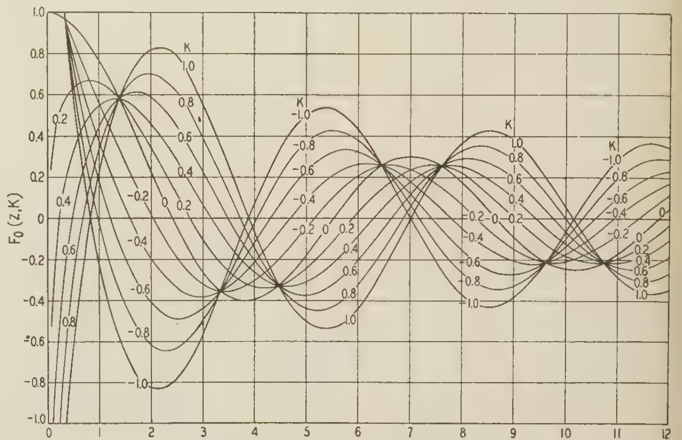


Chart 3. Functions F_o

The generalized oil flow equations are similarly obtained by substituting $L_n(W, t)$ for $e^{-\lambda_n t}$ in eq 2, 3, and 4.

The last 4 terms in the above equation differ from the corresponding terms in the rectangular solution only in that instead of using the constant watts lost after the transient, indicated by the superscript (″), the variable watts loss during the transient, indicated by subscript (t), is used, as explained below. The summation term is identical with the corresponding term in the rectangular solution, except that $L_n(W, t)$ is substituted for $e^{-\lambda_n t}$. The load function $L(W, t)$ is known as the Duhamel Integral, and for the present purpose is as follows:

$$L_n(W, t) = \left[\lambda_n e^{-\lambda_n t} \int_o^t (W_t - W_o) e^{\lambda_n t} dt - (W_t - W_o)\right]$$

Where the losses $(W)_t$ can be expressed as a mathematical function of t, the integral can be formally evaluated. For practical load curves this is seldom the case, and graphical or step-by-step methods must be employed. For the step-by-step method the load function is easy to evaluate when rewritten in the following approximate form:

$$L_n(W, t) = \left[\lambda_n \Delta t e^{-\lambda_n t} \sum_0^t e^{-\frac{W_t - W_o}{\lambda_n t}} - (W_t - W_o)\right] \quad (6)$$

The expression under the summation sign is to be evaluated point by point up to time t (or point B, Fig. 2), using equal finite intervals of time Δt for the preceding period. For good accuracy, $\lambda_n \Delta t$ should not exceed 0.5, and it is best to use the average values of $(W)_t$ and t for each increment term under the summation sign. λ_n and C_n are exactly the same as for the rectangular solution.

At the instant of an abrupt discontinuity in $(W)_n$, the values of $L(W, t)$ for use in temperature equations are:

$$\Delta L_{cn} = -\Delta W_c \qquad \Delta L_{in} = -\Delta W_i \qquad \Delta L_{sn} = -\Delta W_s$$

and for oil flow equations, the correct values of oil flow are calculated directly from:

$$\Delta a_1 = -\Delta W_c \frac{Cc}{Q_1} \qquad \Delta a_2 = -\Delta W_s \frac{Vv}{Q_2} \qquad \Delta a_3 = -\Delta W_i \frac{\epsilon}{q}$$

for the same reasons discussed in connection with the solution for rectangular load change.

Pressure Distribution in Insulation

The principal object or purpose of oil filled cable is the prevention of free gas spaces or open voids in the insulation. One of the chief causes of formation of such voids is the thermal shrinkage of the oil during decreases in cable loading. With the complete solution of the thermal transient available, a thorough investigation can be made of the possibility of this happening from an oil pressure standpoint for any assumed load conditions.

The pressure drop across the wall of insulation depends on the resistance of the paper tapes to radial oil flow. The insulation of commercial cables is often arranged in zones, the density of the tapes being different for each zone. It is necessary to know the dimensions of these zones, and their respective coefficients of friction to radial oil flow. Actual values for the latter have been found to range from 50 to 500 near the sheath, and 400 to 1,000 near the conductor, the units being (lb per sq in.) per (in. cube) per (cu in. of oil per hr) for oil having a viscosity of 50 centipoises.

The process of solution for the radial pressure drop due to a rectangular load change is sufficiently illustrated in Fig. 3. In part 2, a_3 is obtained from eq 4 by replacing r by x if oil feed is from a hollow core only; for feed from sheath channels only, x replaces R. For general load variation the generalized form of the rectangular solution should be used. The calculated pressures, part 4, must of course be altered by an additive constant for hydrostatic pressure so as to make the pressure at the inside (or outside) radius of the insulation equal to the pressure in the oil core (or sheath) at the moment under consideration. If the final resultant pressure is anywhere less than the partial pressure of solution of gases absorbed in the oil, then presumably voids will form.

Following the procedure outlined, a graphical solution of the radial pressure drop was computed for one of the oil filled cables installed in Chicago. Under the most severe conditions of dropping load in the winter, the radial pressure drop was only a fraction of a pound per square inch, or much less than the minimum permissible oil pressure in the core. In the present design of oil filled cables, the radial oil pressure drop is insignificant because of the small viscosity of the oil. However, in solid cables with thick compound this is not so, and the type of analysis given above is useful in determining internal pressures and vacuums developed during load variations.

Verification by Field and Laboratory Tests

The theoretical methods have been found to give results in close agreement with actual measurements in every case which has been checked. For example, the curve of Fig. 4 was selected at random from a series of tests made at the University of Wisconsin. The calculated points are shown by the circles. The agreement between calculated and test

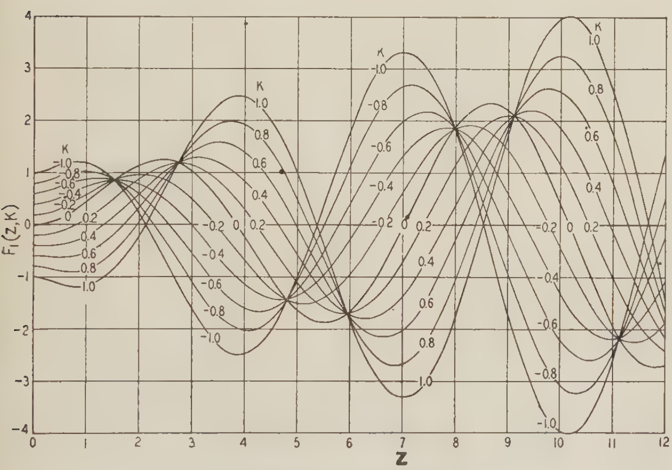


Chart 4. Functions F_1

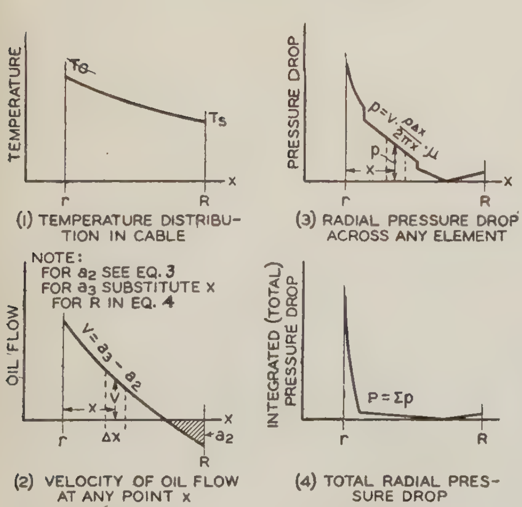


Fig. 3. (Left) Solution for radial oil pressure drop in cable insulation

Illustration is for cable having oil feed from hollow core only

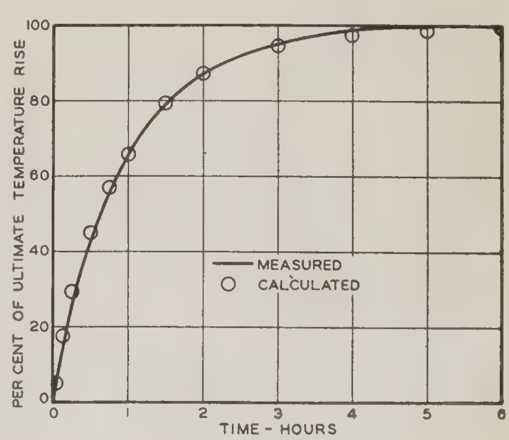


Fig. 4. (Right) Copper temperature transient due to abrupt change in copper losses

Single-conductor 500,000-cm cable having 26/64 in. ordinary insulation and 7/64 in. lead sheath

values is almost perfect except for the latter part of the transient. The disagreement is due to the fact that in the test, the heating current was kept constant. This resulted in a continuous slight increase in the conductor losses, due to the rising conductor temperature. It was not thought worth while to include a correction for this residual effect in the calculations, which are based on the assumption that the conductor loss remains constant after the transient is initiated (see Fig. 1). The last few calculated points, therefore, fall slightly below the test points.

Field tests in Chicago on 2 132-kv oil filled lines provided an opportunity of testing the theory from every angle. In the field tests, a heavy load (200,000 kva in one case) was suddenly thrown on the line, maintained as nearly constant as practicable for several hours, and then suddenly switched off. Records were obtained of conductor current, volumes of oil in feeding reservoirs, and oil pressures at various locations along the line.

The tests were entirely reconstructed by theory, the only known factors being the constants of the cable, the loads employed, and the duct temperature. The results are shown in Tables II and III. Table II provides a check of the slope of the temperature transient curve, as well as of oil flows, since the oil flow depends upon the rate of change of temperature. The agreement is good, and most of the error probably lies in the measured values, since the type of oil reservoirs used made it impossible to obtain precise oil volume measurements. Table III provides a check of the actual cable temperatures as well as of oil pressures, since the pressures depend on the oil viscosity and therefore on the cable temperature. The close agreement between measurement and calculation in Table III is a further indication that the calculated values of Table II are more precise than the measured values. An unavoidable error was, of course, introduced in all the calculations by the necessity of assuming that the duct temperature was the same throughout the length of the cable. Actually the duct temperature probably varied considerably from manhole to manhole.

Table II—Comparison of Measured and Calculated Maximum Rates of Oil Flow During Heat Runs on Northwest-Devon 132-Kv Cables

Line 7,401			
Load-Amp		Max Rate of Flow Gal per Hr	
Initial	Final	Measured*	Calculated
160	420	6.6×10^{-4}	7.2×10^{-4}
400	150	7.3×10^{-4}	7.0×10^{-4}

Line 7,406			
Load-Amp		Max Rate of Flow Gal per Hr	
Initial	Final	Measured**	Calculated
First Test:			
0	950	12.7×10^{-4}	13.1×10^{-4}
830	0	11.3×10^{-4}	11.2×10^{-4}
Second Test:			
0	800	7.1×10^{-4}	9.3×10^{-4}
800	0	8.2×10^{-4}	10.4×10^{-4}

* Average value for 6 sections
** Average value for 3 to 6 sections

Conclusions

1. A simple solution has been obtained for cable transients due to a rectangular load change. The theory has been verified by measurements on actual cables of the ordinary and oil filled types.

2. Mathematical and graphical aids have been developed which greatly reduce the time and labor required for numerical work. Solution and verification of a complete problem formerly required about a week. With the aid of the new methods, the same results can now be obtained in one day.

3. The transients due to load variations of any complexity whatever have been solved by using the well known superposition theorem. Any desired degree of accuracy can be obtained.

4. The duct temperature transient is of importance in problems of variable loading, but has not been adequately investigated. Further work should be done along this line.

5. Some of the constants needed for use in thermal and oil flow problems of cable insulation are relatively new. Many of the values now in use for these constants are based on only a few scattered observations. Further laboratory and field data should be obtained.

List of Symbols

t = time in second
r = inside radius of insulation
R = outside radius of insulation
x = radius of cylindrical element considered
Q_1 = total thermal capacity of copper conductor and free oil in strands and core (if any) per unit length, Joules/deg C
Q_2 = total thermal capacity of sheath, armor, shielding tapes, and free oil in channel or sheath flutes (if any) per unit length
q = specific thermal capacity of insulation, per unit volume
p = specific thermal resistance of insulation, per unit volume
w = dielectric loss per unit volume at unit voltage gradient

Table III—Comparison of Measured and Calculated Oil Pressures in Cable Cores During Heat Runs on Northwest-Devon 132-Kv Cables

	Oil Pressure-Lb per Sq In.			
	Maximum		Minimum	
Sec. No.	Meas	Calc	Meas	Calc
		Line 7,401		
1	28.5	29.4	15.5	14.4
2	26.0	26.0	12.0	11.4
3	25.0	24.4	13.0	12.6
4	26.0	24.1	15.0	14.0
5	26.0*	25.0	13.0	12.5
6	38.0*	37.9	16.0	16.8
		Line 7,406, Second Test		
	20.5	19.2	8.0	7.3
	20.0	19.5	8.0	6.2
	10.0**	8.6	2.0	2.1

* Estimated. Boosters were reconnected at peak pressure.
** Balanced pressure section. Reservoirs disconnected at one end.

E = thermal resistance, sheath to duct, per unit length
G = thermal resistance, copper to sheath, per unit length
T = temperature deg C at point and time considered
T_o = duct temperature
W = watts heat flow across cylindrical element at x
W_c = watts copper loss
W_i = watts dielectric loss per unit length of cable
W_s = watts sheath loss
C = total volume copper conductor and free oil per unit length
V = total volume inside of lead sheath or inside of shielding tape, if any
c = effective volumetric thermal coefficient of expansion of copper core and free oil combined, per deg C
ϵ = effective volumetric thermal coefficient of expansion of insulation, oil and paper combined, per deg C
v = effective volumetric thermal coefficient of expansion of lead sheath, corrected for free oil in channel or sheath flutes, if any
a_1 = rate of oil flow contributed by conductor and core, cu cm per sec per unit length

a_2 = rate of oil flow contributed by lead sheath shrinkage or expansion, corrected for oil in flutes or channels, if any
a_3 = rate of oil flow contributed by insulation
a = total resultant rate of oil flow, per unit length
ρ = resistivity of insulation to radial flow of oil of standard viscosity
μ = correction applied to ρ to take account of actual viscosity of oil
Δ = finite increment of quantity considered

Thermal "constants" are assumed independent of temperature

Subscripts c, i, and s refer to conductor, insulation, and sheath, respectively

Superscript (′) indicates conditions before transient

Superscript (″) indicates conditions during and after transient

All logarithms are to base e.

A Rotary Voltmeter

A new electrostatic voltmeter for measuring either a-c or d-c potentials has been developed; it has a range limited only by its insulation, possesses high accuracy, and draws no current. This article describes the new meter and some of its uses.

By
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DESCRIPTIONS of high voltage voltmeters by the dozen may be found sprinkled through the literature of engineering and physics, and in the face of this wealth of invention the proponent of yet a new one feels required to justify his entrance into the well filled field. The defense offered in this case lies precisely in this abundant bibliography and in the thought that these continued and varied efforts strongly suggest a problem still unsolved. Instruments excellent in some respects have generally purchased such excellence by sacrifices in other respects. Highly accurate electrostatic voltmeters acting upon attraction or repulsion principles have been constructed, but unfortunately they are non-portable, non-linear, and dependent upon other meters for their calibrations. Spark gaps are rugged, portable, and simple to construct, but their limitations in other respects are too well known for comment. Wire-wound high resistances of good design, used in conjunction with a galvanometer or potentiometer, are accurate and highly satisfactory to those who can afford them, at least in constant potential applications. In some cases, however, the load which they impose upon the high potential source is undesirable.

Prepared especially for ELECTRICAL ENGINEERING. *Not published in pamphlet form.*

The instrument to be described here operates according to principles which are thought to be new in high potential measurements, and accordingly it possesses a set of characteristics not duplicated in other existing meters. Fortunately, practically all of the well-known defects have been avoided, and no new ones have appeared during a testing period of more than a year in routine service, unless the noise produced by the running of a small motor be accounted a defect.

Briefly this is a rugged and portable a-c or d-c voltmeter of unlimited range, high accuracy, short period and linear scale characteristics. It draws no current, has no detectible temperature errors, and is not unreasonably difficult or expensive to construct. The indicating instrument is at earth potential and may be located remote from the rest of the meter. The calibration of this meter inheres in its construction and may be established without recourse to any high potential manipulations whatever.

Central unit of the meter is a contrivance which may be called an electrostatic generator. It has several points of analogy with a simple 2-pole, separately excited electromagnetic d-c generator. In the electrostatic generator a simple armature rotates in the electrostatic field existing between 2 pole pieces

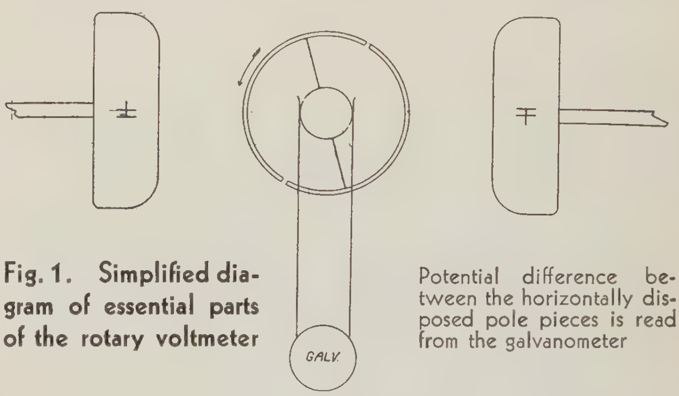


Fig. 1. Simplified diagram of essential parts of the rotary voltmeter

Potential difference between the horizontally disposed pole pieces is read from the galvanometer

whose difference of potential is to be measured. The armature, driven at constant speed by a synchronous motor, generates a direct current which is directly proportional to the potential difference applied to the pole pieces. This generated current is conducted to a suitably calibrated galvanometer or microammeter, from which the value of the applied potential may be read directly. The whole assembly is termed a rotary voltmeter.

Essentials of the meter are shown in Fig. 1. The so-called armature is a piece of metal tubing which has been sawed longitudinally into 2 equal semi-cylinders. These are connected electrically only by the path leading through the commutator and galvanometer. When the meter is in operation, the galvanometer receives a pulsating direct current the average value of which, as shown by simple theory and many experiments, is given by the formula $I = 2CVn$, in which V is the applied potential

Fig. 2. Rotary voltmeter for measuring potentials from 1 volt to 110 kv; complete except for galvanometer

(here supposed constant) n the speed of rotation of the armature in revolutions per second, and C the capacitance of a system comprised of the armature and one pole piece. This equation has been checked exhaustively on 3 different generators, in many cases with all relevant quantities independently measured; it holds rigorously over a wide range of voltage.

The generator shown in Fig. 2 was built for measuring potentials up to 110 kv. The upper limit is set only by the limitations of the insulators and the width of the gaps between the pole pieces and the rotor. The wide range of potentials measurable with this meter and the proportionality existing between potential and generated current over the entire range are displayed by the graph in Fig. 3. The circled points represent corresponding values of independently measured applied potentials and generated currents. Currents such as those designated at the lower end of the graph require a rather sensitive galvanometer for their measurement, but up in the practically useful part of the range a portable microammeter of the pointer type or a switchboard microammeter is perfectly adapted and most convenient.

Calibration constant of a voltmeter of this type may be determined either by applying a known potential of a few hundred volts and measuring the resulting current, or by measuring the capacitance C and taking account of the known speed of rotation. Both methods have been found to be practical and easy and the resulting calibrations to be correct to within a small fraction of one per cent. It is found in most cases that the accuracy of the rotary voltmeter is simply the accuracy of the indicating instrument itself. Calibration methods have been more fully described in another article published in *Review of Scientific Instruments*, v. 3, 1932, p. 430–8.

As mentioned previously, the rotary voltmeter is useful for measuring alternating as well as direct potentials. Close analysis of the generating process shows that the only potential difference of significance in the equation $I = 2CVn$ is the potential difference existing when the semi-cylinders of the rotor are turned directly toward the pole pieces, that is,

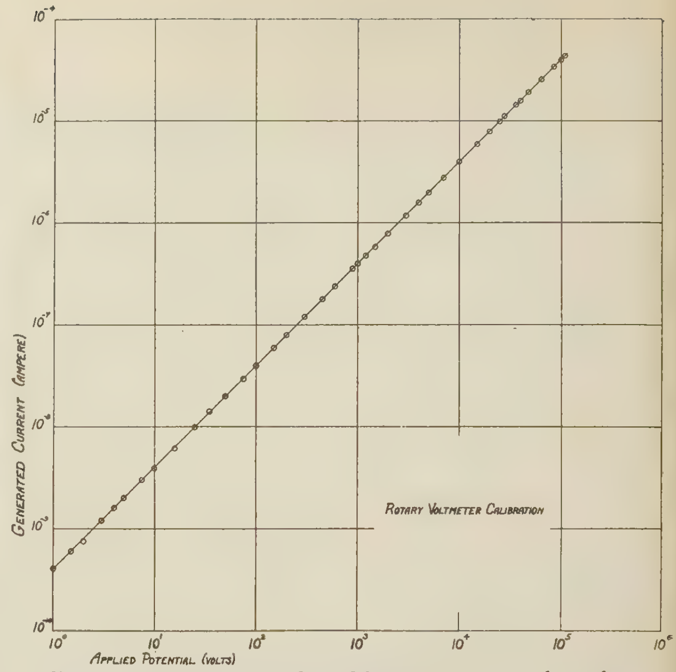


Fig. 3. Experimental calibration curve for the instrument shown in Fig. 2. The curve is straight and agrees with the theoretical equation $I = 2CVn$

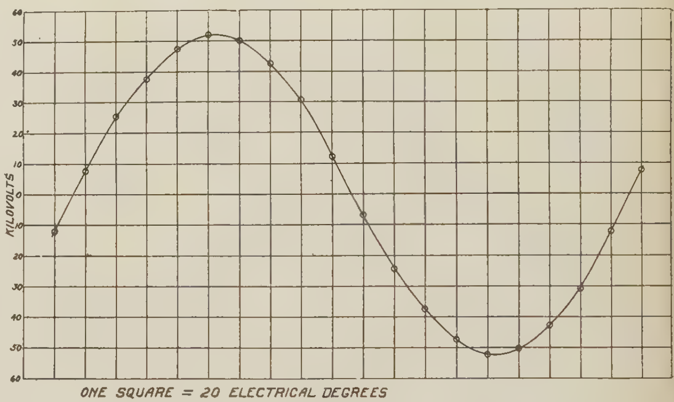


Fig. 4. Potential wave form across the secondary terminals of a high voltage transformer, as determined with the rotary voltmeter

at the instant of commutation. In other words, the generated current is proportional to the *instantaneous* value of the applied potential at a certain instant during the rotation. If the rotor is driven by a 4-pole synchronous motor connected to the same power system as that which furnishes the potential to be measured, this instantaneous value recurs identically twice in each revolution, that is, at each commutation point. The voltmeter then measures this instantaneous potential, regardless of the potentials that may obtain during other parts of the cycle.

By advancing or retarding the rotor in its synchronous rotation various potentials along the applied voltage wave may be determined in turn and the entire wave form expeditiously plotted in a point-to-point manner. This control of the rotor phase has been accomplished in two ways: by bodily rotating the motor a portion of a revolution about its own axis; and by operating the motor on current from a

phase shifting transformer. The latter method, which has the advantages of greater simplicity and convenience, was employed in determining the output wave form (see Fig. 4) of a high voltage transformer.

High potential wave forms for various conditions of rectification, filtration, and load have been determined by this method. When it is desired to measure only the peak value of an alternating potential the rotor phase may be set for the maximum generated current and left in that adjustment. These voltmeters so far have been used only in a few experimental X-ray laboratories, but their dependable and inconspicuous performance in these cases suggests that they will be found useful in a variety of other applications.

Pneumatic Tired Diesel Electric Rail Car

A DIESEL electric rail car having a body of stainless hi-tensile steel construction and running on pneumatic rubber tires has recently been delivered to the Reading Company. Much fundamental development work in the building of this 47-passenger car was done by the E. G. Budd Manufacturing Company, involving the forming and handling of thin sheets of steel, and requiring considerable research into methods of welding. As the result of this work the weight of a self-propelled car of a given seating capacity has been reduced to 33 per cent of the weight of the accepted passenger coach having no power as used on Class I roads.

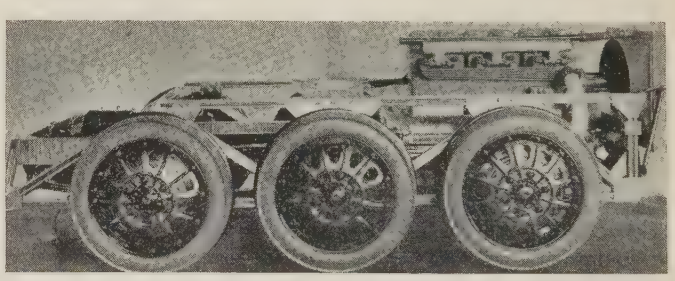
The front or power truck is equipped with a 125-hp Cummings diesel engine directly connected to a Westinghouse 250-volt generator of special light weight construction. In the power truck also are mounted the batteries and control. The rear or traction truck is a single high speed Westinghouse motor mounted under the bolster. The double extended shaft drives the front and rear axles of the traction truck through a Timken differential worm gear having a ratio of 9.1 to 1.

The trucks, of unusual design, are of light weight construction. The power truck has a "shot-welded" stainless steel frame weighing 281 lb, while with the engine, generator, batteries, axles, wheels, etc., the total weight is 6,990 lb. In the traction truck the "shot-welded" stainless steel frame weighs but 230 lb, whereas the motor, axles, wheels, etc., make the total weight 4,315 lb.

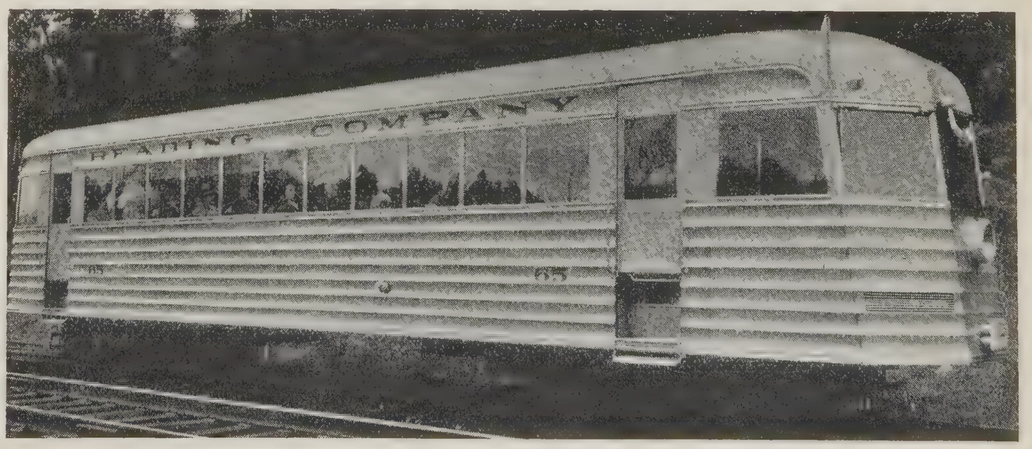
The interior of the car is of extremely simple design, the vestibule being free of any obstruction from the engine. Lighting receptacles are recessed on either side of the exhaust ventilating duct which runs along the center of the car, resulting in a very pleasing and efficient scheme of indirect lighting.

The windows are permanently closed, keeping out the dirt and much of the noise. An ingenious ventilating system takes in air on either side of the car at the step wall and by a motor operated fan distributes it along either side of the car. In winter the air is drawn through a radiator heated by water from the engine. The air is then distributed by conduits evenly through the car. A radical design of reversible seat has been used, the double seat with rubberized hair and leather covering weighing but 50 lb.

Stainless steel marker lights are built neatly into each of the 4 corners of the car. Automatic air engines operate the side doors, trap doors, and folding step, as a unit. The controls of the car are simply arranged for operation from either end of the car.



The front truck of the diesel electric car. This truck carries a 125-hp diesel engine and direct connected 250-volt generator. Batteries and control also are mounted on this truck. The rear truck, not shown, carries the traction motor



Pneumatic tired diesel electric rail car of stainless hi-tensile steel construction. No paint is used on the outside of the car, the stainless steel permitting a permanent luster finish. The car is 51-ft in length, weighs approximately 22,000 lb, and has a speed of from 50 to 55 mph. The tires are 33 x 4½ in., and carry a pressure of 95 lb

Oil pressure, water temperature, and engine speed are all relayed by light circuits.

The rapid acceleration of the car, the riding qualities of the pneumatic tired wheels and the exclusion of noise and dirt combine to give an extremely pleasant reaction to the passenger. When properly applied economies may be secured by this type of high speed light weight self-propelled car which should make it attractive to the railroad operator.

Usury on Labor

Too great success in cornering our mediums of production is considered responsible by many for our present industrial instability; the result is usury on labor. This is the fifteenth article in the Engineering Foundation's symposium "Has Man Benefited by Engineering Progress?"

By
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Research and Development Engineer, Bolton, Canada

MACHINES now idle that were running 24 hr per day in 1928 and '29, create a situation demanding correction. Not many years ago we had a moneyed class able to aid liberally in the support of education and general culture, with machinery operated 10 hr per day; with better machines running 24 hr our moneyed class has not been able to keep the business ship on an even keel nor to provide those conditions which history shows are usually a preventive of radical measures and social unrest. After 2 or 3 yr with machines manned by shock troops 24 hr per day, we are having more than 2 yr with those machines largely idle. The cause is declared an obscure mystery. What we learn from this mess is going to depend upon what we do about it.

Our sires thrived on the 10-hr day. We have more machines, better machines, a more elaborate organization; and in many lines we are overtooled. As soon as a commodity appears to be attractive commercially, too many rush to make it. Where a market is obtainable, 24-hr operation is taken as the ideal. Under our system capital thus leads the rush and tears along like an engine without a governor; but systems, like engines, can destroy themselves if ungoverned.

Now we know (after being forced to learn) that long hours of labor per shift are not best for economic production and social progress. Is it not, therefore, possible that 24-hr operation of machines, though admittedly representing 100 per cent load factor for money invested, has some wide influence which is highly pernicious to business and social harmony? May not more cooperative planning, even internationally, be essential in order to govern the capitalistic engine as now massively and highly developed?

Success in business has too long been significant of predatory characteristics; but has any national organization based upon war and predatory behavior long survived? Why in peace time the pressure of 24-hr operation of machinery? Under what circumstances is it socially permissible? What relation should hours of machine operation per day bear to hours of labor for each shift?

Cornering Has Been Going On for Ages

For ages there have been attempts by some members of a community to corner the prevailing medium of exchange, and to release it for use by other citizens only on prepayment of excessively high interest. This is usury on money, and there are state laws respecting it. Respecting mediums of *production* we still are without proper correctives against cornering. Too great success in cornering our mediums of production, among which labor takes first place, is considered responsible by many for our present industrial instability. Before society can enjoy the activities of labor and benefits from engineering progress, a few persons who are in control demand an over-large portion of the returns for themselves. In short, the result is *usury on labor*.

Social welfare and stability demand, therefore, that all workers shall share in the greater returns from an improved load factor of a manufacturing plant. Should the market warrant 12-hr operation of machinery, then let there be, say, 2 shifts of 6 hr each; if 20-hr operation, 4 shifts of 5-hr each; if 24-hr operation, 6 shifts of 4-hr each, the pay to remain approximately the same *per shift*.

With such pay, employes could better meet the fluctuations in employment likely to occur for some years, until we arrive at a better social-industrial organization. This procedure would offer to all concerned in manufacture an incentive for improving the product and its market. The unequal hours in different industries might draw the better grade of workers to places where the hours were most favorable. This would be placing benefits among those workers most likely to benefit society, and whose betterment would provide opportunity for their higher self-development and culture with more inspiration for their children—social stabilizing conditions such as are becoming eliminated in the present militarized industry with the larger benefits and privileges going to an extreme few at the top.

Editor's Note: Pursuant to the invitation of the Engineering Foundation, the editors will be happy to receive comments, criticisms, or discussions pertaining to this or other articles published in this series.

Telephone Cables in Large Buildings

Design of telephone facilities for large buildings requires the careful consideration of a large number of factors to insure that the telephone plant shall be used with the maximum degree of efficiency. The factors which must be considered are outlined in this article, which is a portion of the authors' complete paper on the general subject of cables for telephone distribution.

By
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PLANNING of telephone facilities for large buildings is a problem which rivals in importance the planning of the telephone distribution system between the central office and the customer's premises. Telephone cables used for distribution within a building are termed "house" cables. Close cooperation is necessary between the telephone engineer and the owner, architect, or contractor in order that the house cable system may be designed to conform to the building layout, and in order that the building plans may include the provision, by the owner, of the necessary shafts, conduit, cabinets, and other housings for that house cable system.

Building Cable Design

In considering the problem of furnishing telephone service to large buildings, it is quite impracticable and uneconomical to place a pair of wires through the building each time a telephone is required. Buildings of these types are generally given service by means of house cable which is placed in the building during its construction, and provides facilities which will permit convenient and efficient connections of telephones at any location within the building. The house cable system is usually designed to meet the maximum requirements of the building with sufficient flexibility to care for any changes in the relocation of the telephones or for any rearrangements to the building.

These systems usually consist of one or more riser cables starting directly from an entrance cable or from a main cross-connecting terminal or frame in the basement, and extending up through shafts or conduits of the building. Branch cables on each floor are terminated at suitable distribution points by means of floor terminals, where connections are made to the subscriber's telephones by wires.

The general arrangement of the house cable system is almost identical to the general outside plant arrangement in a central office area in that the riser cables may be likened to the main underground cable, the floor branch cables to the subsidiary distribution cables and the floors themselves to individual blocks or areas along a feeder route.

Class of Buildings

For the purposes of house cable design, large buildings are put into one of 2 classifications, depending upon the expected permanency of stations, both as to number and location, as follows:

1. *Office and loft buildings* in which telephones do not remain fixed either in number or location for any extended period but vary with the requirements of the individual, who will use more or less telephone service according to respective activities.

2. *Hotel and apartment houses* in which the number and location of telephones are fairly definitely fixed by the number and arrangement of rooms or apartments in the building and the telephone service required by successive occupants is approximately the same.

Planning for Requirements

Unless suitable housing facilities are provided in advance for accommodating cables and wires and for passing them through the walls and floors, either exposed telephone installations will result in unsightly conditions, subject to possible damage with subsequent undesirable effects on service, or extensive costly alterations may be required after completion of the building to conceal effectively all cables and wires. These systems of housing facilities include cable and wireshafts, conduit boxes, molding raceways, underfloor ducts, etc., and are designed to conform to the maximum requirements in common with the water, gas, electric light, and power conduits as an integral part of the building. The vertical accommodations (for the riser cables) start from the basement and rise to the top floor connecting at the various floors with horizontal housing facilities, and junctions between cable conduits are effected by means of splicing closets or splicing and terminal boxes whereby complete passage is afforded for cable and wire from the basement to the location of the station.

Consideration is given to the intended present and future use of a building, the character of its location and average rental value in order to design the cable plant to meet the conditions. Experience has shown that maximum circuit requirements have a definite relation to rentable or productive floor area and this relation is the basis for both house cable and housing system design. Pair density factors expressing the relation between rentable or usable floor area and cable pairs provided have been developed for certain cities by an analysis of the use being made of house cable in existing buildings. From these data broad averages have been derived in the form of ranges of

Full text of a portion of "Use of Cables for Telephone Distribution Purposes" (No. 32-121) presented at the A.I.E.E. Middle Eastern District meeting, Baltimore, Md., Oct. 10-13, 1932.

the number of riser cable pairs per unit of floor area which would provide liberal facilities for the developments realized. These factors are used in determining the amount of facilities to be provided in any particular new problem by applying them to the rentable or usable floor areas.

Cable Entrance and Main Cross-Connecting Terminals

The cable entrance point is selected with the object of establishing the shortest satisfactory route from the point of connection with the feeder system. Cables are preferably attached to walls or ceilings rather than to partitions which are subject to removal or changes. The number of entrance cable pairs to buildings not served largely by one or several local switchboards is determined in the same manner as the facilities to be provided within the building. The number of entrance cable pairs in a building having private branch exchange service is designed to meet the requirements of one or several switchboards; that is, provide trunk lines, telephone power lines, and facilities for outside extensions, if any, including a surplus of pairs to insure adequacy and also provide central office feeders for stations other than extensions on the switchboard. In some cases the building entrance cable includes facilities for extensions to the adjacent block plant.

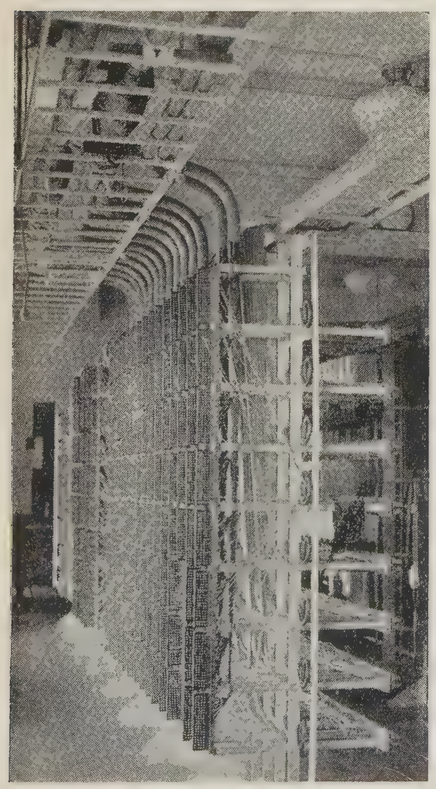
The main cross-connecting terminal or frame, shown in Fig. 1, is usually in the basement at or near the foot of the riser shaft or conduit. The specific location should be determined upon in advance of the building construction in order that the required space may be set aside and the necessary housing accommodations be installed as the building is erected.

Riser Cables and Housings

Riser cables, Fig. 2, are designed as nearly as practicable to intersect the floors at the wire centers as determined by study of the typical floor plans. Specific location for the riser cable housing is preferably a permanent corridor partition or in the wall of some public place leading from the corridor and easily accessible without annoyance to the tenants of the building.

In buildings having large distribution areas or in which each floor is made up of several distinct distribution areas, 2 or more riser systems may be desirable, each being used to serve a definite floor area centering about it. In office buildings containing several riser systems, these systems are tied together at certain floors with conduit of sufficient size to house a cable containing enough pairs to permit concentrating the entire floor system on any one riser.

Floor cable and wire housings in combination, afford passage for the telephone circuits from the riser system to the approximate locations of the individual telephones. Cable housings extend more or less directly from the riser to wiring centers on the floor where floor distribution terminals are located and where connection is made with the housings for wire. The floor cable housing system must accommodate a floor distribution cable plant which provides adequate facilities to meet the demand for telephone service on the floor wherever and in whatever quantity it may be. The first step in the design of the system is the determination of the number of cables, including terminals which it will house, their location and size. In small buildings, where the amount of floor distribution is not extensive, the housing system may carry cables and wires together in such raceways as hollow moldings or baseboards. In most



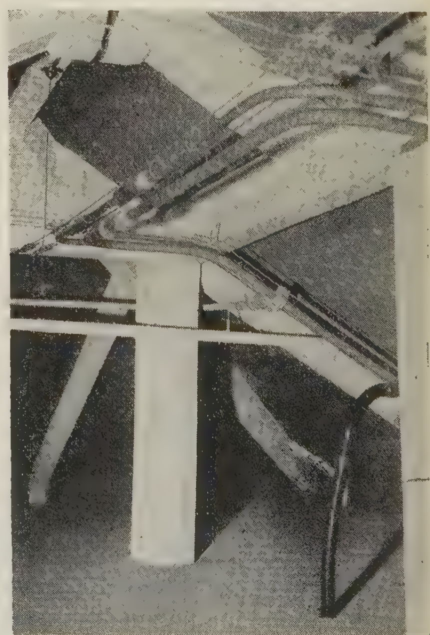
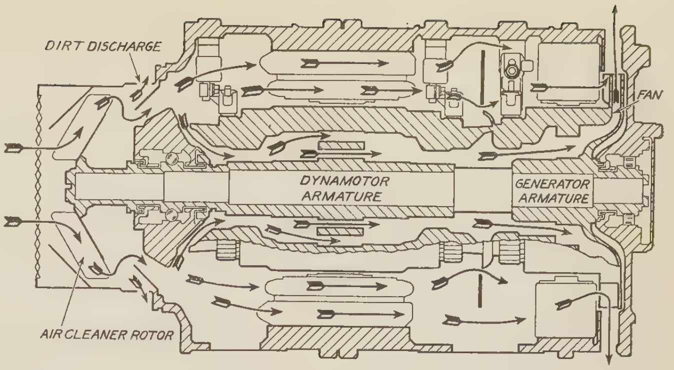


Fig. 1. (Left) Cross connecting frame in building

Fig. 2. (Middle) Section of house cable system in loft of large office building, showing type of riser cable shaft and riser cables

Fig. 3. (Right) Section of house cable run in loft of large building

buildings, however, separate systems for cable and wire are necessary, although it is usually quite practical and economical to place small cables in lieu of wire in housings intended for wire when special distribution requirements make this desirable.



A self-ventilating duplex railway machine

Centrifugal Air Cleaners Serve Railway Equipment

Here is given a description of a railway dynamotor-control generator set designed for compactness and fitted with centrifugal air cleaning device, as used on cars for the Lackawanna electrification.

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THE DESIGN, and particularly the ventilation of the dynamotor-control generator sets used on the 3,000-volt d-c motor cars in service on Delaware, Lackawanna & Western Railroad, involve several features which are somewhat unusual for electric motor car equipment. This set provides a 1,500-volt source of power for the compressor and 40 volts for lights, control, and storage battery charging.

To avoid encroaching upon available passenger space, the set was mounted feet up under the car body between the trucks where the ventilating air available is likely to be dirty. Because of the long ducts that would have been required it was considered impractical to obtain an air supply through the settling chambers provided over the vestibules to supply air for the traction motors (J. C. Aydelot, "Motors for 3,000-Volt Multiple Unit Cars," Electrical Engineering, June 1932, p. 401). The alternative of totally enclosing the set also was discussed, but the machine could be made so much smaller and lighter if well ventilated that the idea was rejected. Since centrifugal air cleaning devices to furnish about the same volume of air already were in use in other classes of service, a test machine was constructed with such a device and tests were made to determine the cleaning efficiency. On test the cleaner performed creditably, removing from the air practically all the denser materials such as iron filings and a large percentage of the lighter materials such as powdered talc. These materials were selected for the test as being comparable to brake shoe dust and fine snow, the two most detrimental materials normally encountered. For approximately 2 years these machines have been in service on 141 motor cars, without any trouble chargeable to foreign matter in the ventilating air.

General design of the entire set is shown in the accompanying sectional view where it may be seen that the radial blades of the centrifugal cleaner impart a swirling motion to the entering air which causes all particles heavier than the air to be thrown to the outer casing of the cleaner. As the air is drawn toward the machine by the exhaust fan a conical splitter divides air stream; the air near the surface of the casing and carrying most of the dirt being ejected, and the air remaining at the center entering the machine. The clean air then is divided further: one stream passes over the commutator, around the brush holders, through the air gap and the spaces between the field coils, and out through the fan and exhaust openings; the other stream passes beneath the commutator, through the longitudinal ducts in the armature cores, and out through the fan and exhaust ports.

Although the control generator is a low voltage machine and hence not readily rendered inoperative by dirt, a supply of clean air for it, too, is highly desirable in order to reduce both brush and commutator wear by excluding most of the abrasive matter from the cooling air. To enable one cleaner and one fan to serve the set, the motor and the generator are ventilated in series, with the generator in second position principally because it is the smaller machine and because the low voltage permitted more flexibility in design. However, since the volume of air used is so great that the temperature rise of the air in passing through the dynamotor is only about 14 deg C, the increase in generator size due to the prewarming of the air is unimportant and is believed entirely justified by the lower generator maintenance.

Mounting the generator within the dynamotor frame, while done primarily to obtain clean air, presents several other advantages:

1. To reduce the over-all length of the set to a minimum, and thereby permit a short, stiff shaft to be used, the control generator was made abnormally large in diameter and short. As a separate machine of this diameter the weight and space of the generator would not be economical, but as an addition to machine of inherently large diameter, the weight and space requirements actually are less than if a smaller diameter had been used.

Written especially for Electrical Engineering. *Not published in pamphlet form.*

2. The problem of obtaining good commutation was simplified by the short length of core which decreases the sparking reactance voltage.

3. The large generator diameter makes possible a large radial air space between the bearing and the end windings permitting the bearing to be recessed under the fan, thus shortening the set.

4. Maintenance cost is less because the control generator need not be removed before disassembling the armature, as probably would have been necessary with an overhung design.

When operating at a 2,700-volt average trolley potential the dynamotor will deliver 4.6 amp from the mid-tap for the operation of the air compressor. Simultaneously from the control generator a maximum continuous output of 4.5 kw at 40 volts is available without exceeding a temperature rise of 85 degrees C by resistance in any winding.

The set is semi-fabricated and weighs 2,630 lb complete with air cleaner. Provision is made for convenient inspection of commutator and brushes through openings in the frame normally covered by flexible strap girdles. To insure against the high voltage of the dynamotor being imposed upon the low voltage circuits of the control generator, should an arc to ground or a flashover of the low voltage dynamotor commutator ever occur, a steel flash barrier separates the two commutators which are adjacent and in the center of the set.

Locating Faults in Power Cables

Power cable fault locating is at times difficult due to a high initial fault resistance or an increase of resistance during the time locating is in progress. A method using a constant current transformer for reducing high initial resistance and preventing its increase, in connection with a short circuiting switch to generate signals for locating the fault, is discussed in this article. A practical assembly of this type of apparatus for cable fault locating is described and operating directions are included.

By
W. P. TAYLOR
ASSOCIATE A.I.E.E.

Consolidated Gas Elec. Lt. and Pwr. Co. of Baltimore, Md.

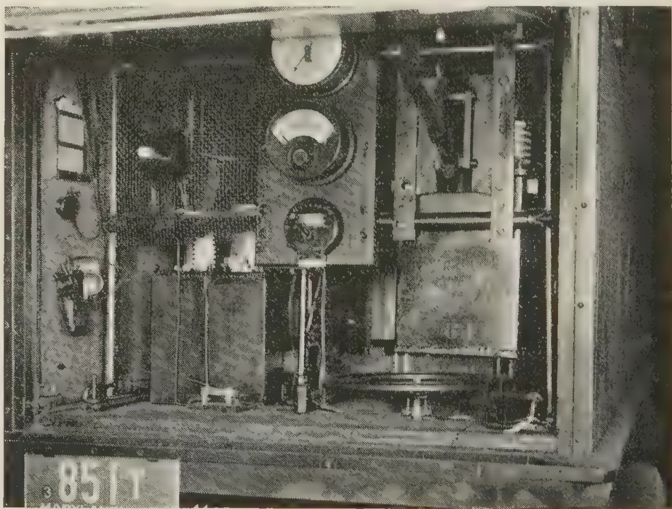

Fig. 1. Front view of portable cable fault locater mounted on a $1^1/_2$-ton trailer

A 50-kw 6.6-amp constant current transformer is used to furnish current for carbonizing the fault and signaling. The low voltage rating is 2,300 volts and 25 cycles. The 2 high voltage coils can be connected in series or in parallel; connections are by wingnut and bolt, with a fiber sleeve for insulation over the connection. Coil position is regulated by the hand wheel. Steel spark gaps limit the maximum voltage delivered. The meters on the panel indicate the current and voltage being applied to the cable. A 200-va potential transformer supplies 2 lights and power to drive the rotary shorting switch

THE LOCATION of power cable faults has been facilitated by the design of the portable cable fault locater shown in Figs. 1 and 2, combining a constant current transformer and short circuiting switch with suitable accessory apparatus. Two general methods are in use for locating faults in power cables. One of these involves the use of a bridge to measure the resistance of a conductor to the fault and thus gage its distance from the test station. The other method, and the one on which this portable fault locater is based, requires a signal current to be passed through the conductor to the fault. With this method an exploring coil is held successively at different points along the faulted cable, and an audible indication of the fault location is given by a head-phone connected to the exploring coil.

An investigation started several years ago indicated that the audible signal method was preferable and that some scheme was necessary for reducing the resistance of high resistance faults, and maintaining the fault resistance constant at a low value during the test period. These requirements have been met in the portable fault locater by the use of a constant current transformer for burning and reducing

Esentially full text of "Locating Power Cable Faults by Means of a Constant Current Transformer With Short Circuiting Switch" presented at a meeting of the A.I.E.E. Baltimore (Md.) Section, May 15, 1931. This paper was awarded the 1931 A.I.E.E. Middle Eastern District prizes, both for best paper and initial paper.

cable faults as well as the generation of a signal current, obtained by means of a rotary switch which intermittently short circuits the secondary of the constant current transformer. A schematic diagram of the cable fault locater is shown in Fig. 3, and the rotary shorting switch in Fig. 4. The great advantage of this method is that the fault is not lost during the process of locating. A not unusual and extremely exasperating experience in fault locating by some other methods is the frequent loss of faults due to healing when low voltage signal current is used, requiring repetition of high voltage tests.

Fault Reduction

The previously known advantages of a constant current transformer for burning a cable fault are utilized in this equipment. If a fault exists and the voltage applied is high enough to cause an appreciable current flow, the fault will commence to carbonize and the resistance will be reduced. Where the resistance is high, advantage frequently may be taken of the fact that the capacity of the cable in conjunction with the reactance of the transformer may give a condition approaching resonance, thus increasing the applied voltage in excess of the open circuit voltage of the transformer. The different voltages which are possible are illustrated in Fig. 5. A spark gap connected across the cable eliminates the possibility of dangerous voltages in case there is no cable fault to retard the rise.

The initial voltage available for application to the cable can be varied by changing the amount of connected cable capacity or by changing the inductive reactance of the constant current transformer through a change in coil connection or position. The characteristics of the transformer limit the current to a safe value, and after reducing the resistance of the fault, the current maintains this resistance constant at a low value while the signal current is generated by the rotary shorting switch. The nearly continuous carbonizing effect of the power current is thus obtained simultaneously with the sending of the signal. Tests have proved the method quite satisfactory in regard to signal quality, and in addition a long life of switch contacts is secured due to the absence of high voltage during operation of the shorting switch.

Operation of Cable Fault Locater

The portable cable fault locater shown in Figs. 1 to 4 is held is readiness in a station where most trouble is expected. Tie cables frequently can be used to connect the locater to faulty cable at other stations. The actual operating procedure for locating a cable fault with this equipment may be outlined as follows:

1. As soon as a fault has occurred, the cable in trouble should be isolated from all apparatus by opening the pothead disconnecting switches. No checking for faulty phase or continuity is necessary.

2. With cutout and oil switch on the locater open, connections are

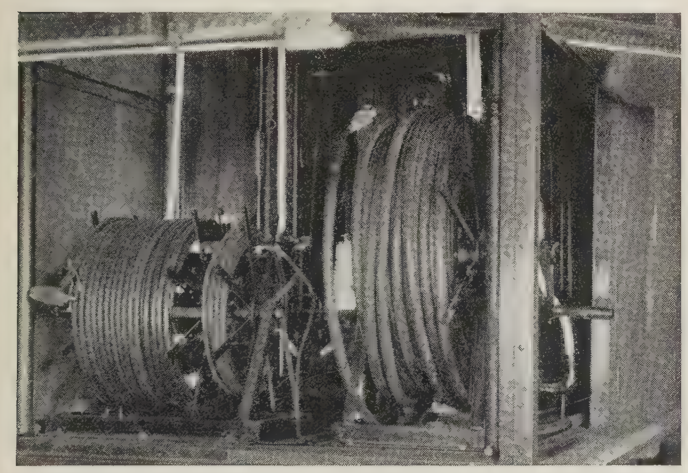

Fig. 2. Rear view of portable cable fault locater

Reels hold lengths of insulated leads for connecting to power supply, ground, and faulty cable. These reels can be locked in position. Removable handles are used when the leads are to be wound up. Suitable clamps are used on the lead ends to facilitate connecting. Connection between the leads on the reels and the wiring on the trailer is made by wingnuts and bolts, with fiber sleeves for insulation

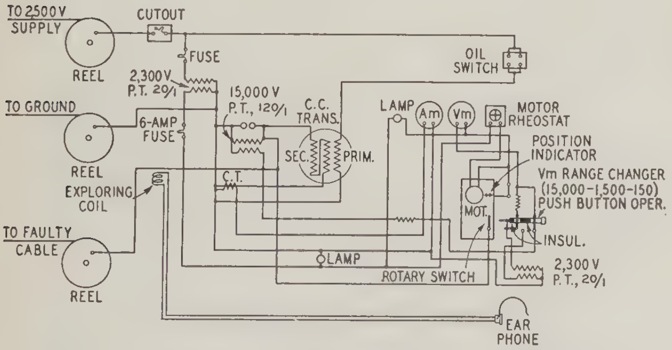

Fig. 3. Schematic diagram of cab!e fault locater designed primarily for 13,000-volt power cables

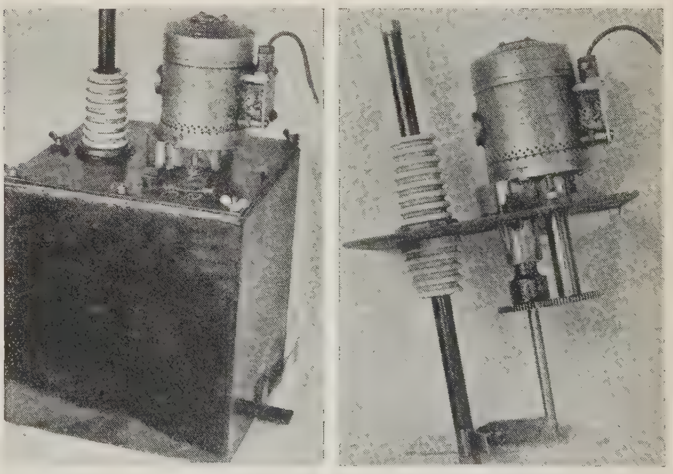

Fig. 4. Rotary switch for intermittently short circuiting the secondary of the constant current transformer in order to utilize the fault reducing current as signal current

An electric drill with a universal motor is used to supply power and reduction gearing. The fixed contact is copper and the moving one is sheet brass or bronze. Oil is used in the tank for insulating and cooling. An indicator needle on the top of the casing and connected by gearing with the moving contact shaft shows the position of the moving contact. A rheostat controls the speed of the motor

now made to ground, a 2,300-volt supply (either 25 or 60 cycles) and the 3 conductors of the faulty cable at its pothead disconnecting switches. (If isolated phase system is used, test bus can be used, tying in at the most convenient point.)

3. The 2,300-volt cutout on the locater is now closed. A lamp now lights on the trailer and indicates the supply is alive up to the oil switch. The transformer coils are now set at a maximum distance apart.

4. After first checking that the rotary switch is open, the locater oil switch is closed, and the voltmeter is read. If the voltage wavers, current is being passed through the fault and it is allowed to burn for a while. If the voltage drops rapidly, the carbonizing is satisfactory. If the dropping in voltage takes place slowly it can sometimes be speeded by paralleling the secondary coils or moving the transformer coils closer together. In any event the burning process must continue until the voltage is quite low. For best results it should be 100 volts or lower with the current at 6.6 amp before the signal is put on.

5. In case the voltage does not vary after the cable is made alive, no burning action is taking place. If the voltage shows below the open circuit voltage of the constant current transformer, the connected cable has too great a capacity. To reduce it, reduce the number of phases tied to the locater, tying the extra ones to ground. Now apply voltage again with the locater. If a voltage above open circuit is reached with no evidence of the fault burning, it is probable that the faulty phase is tied to ground. Switch phases and try again.

6. After the fault has properly carbonized, indicated by the voltage being steady and below 100 volts at 6.6 amp, the signal is put on the cable by running the rotary shorting switch. Listening to the phone the speed of the shorting switch is adjusted, by means of the rheostat, to give a ticking sound at about 200 cycles per min.

7. The exploring coil and phone shown in Fig. 6 are carried to cable manholes. Hearing the signal in one hole and getting no signal at the next hole away from the sending station, indicates the fault is between the 2 holes. Care should be taken to place the exploring coil on the cable beyond the cable bonds on the side away from the sending station.

A record of voltages and currents, time to carbonize and locate, should be kept together with notes on the fault. After a little experience with the action of the locater on various type faults, some prediction can be made as to the type fault and whether located in a wet or dry place.

Actual Cable Faults Located

During a period of $1^1/_2$ years previous to the design of the locater described, 26 power cable faults on the system of the Consolidated Gas Electric Light and Power Company of Baltimore were located successfully by the use of constant current transformer equipment, using 15-kw, 30-kw, or 50-kw transformers. During this period there was only one failure to locate the fault, and this was caused by a personal error and was not due to any defect in the method.

Records have been kept for all faults located (mostly on 13,000-volt cable) and these show that although some stubborn cases required over 2 hr from the time voltage was applied until the fault was located, the great majority required less than one hr. In almost all cases, the fault resistance was reduced sufficiently in a very few minutes so that the test signal could be applied. Voltage readings were taken during each test and these show that on 13,000-volt paper insulated lead sheath cable, some faults may require an initial voltage of 15,000 volts or higher in order to start carbonization of the fault. As the open circuit voltage of a 50-kw 6.6-amp constant current transformer is only about 8,000 volts, the value of the resonance relation for boosting this voltage is quite evident. The maximum voltages measured covered the range from over 15,000 volts down to almost zero, indicating a wide range of fault resistances.

In quite a number of cases smoke could be seen leaving the duct or could be smelled at the manhole near the fault, thus indicating the close presence of the burning fault. As the current is limited to 6.6 amp there is no damage to nearby cables and yet the current is sufficient to cause a small amount of smoke in most instances, thus assisting in locating the fault.

Two faults in 4,000-volt cables were located and these generally required the application of less voltage. Three faults in 26,000-volt cables were located, 2 of these being in submarine cables. The latter cables, being submerged in water, are particularly difficult to handle, although the appearance of bubbles in the water over the fault may assist in the fault location. A large exploring coil with simple 2-stage amplifier and head-phones carried in a row boat, have been used to locate faults in submarine cable, although some difficulty in distinguishing the signal was encountered over deep water (35 ft) due to the number of foreign sounds picked up. In this case, however, the vicinity of fault was located, and the cable was pulled up by a grappling hook quite close to the actual fault.

Although constant current transformers have been used previously for reducing cable fault resistance, the use of the constant current transformer both for reducing the fault resistance and for sending a signal to locate the fault is believed to be original. That these ideas are practical has been proved by the record of successful operation on a large number of power cable faults.

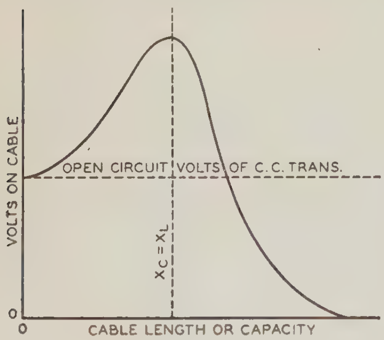

Fig. 5. General shape of curve of voltage applied by a constant current transformer to a cable without fault

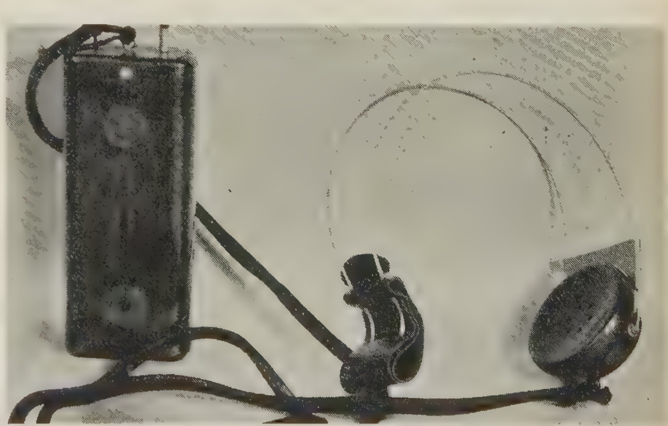

Fig. 6. Small exploring coil and head-phone normally used to locate the manholes between which the fault is located

A larger coil and amplifier are used in special cases where it is impossible to put the coil directly on the cable sheath

News

Of Institute and Related Activities

Winter Convention Technical Program Announced

PLANS for the technical program as tentatively arranged for the coming winter convention of the Institute to be held in the Engineering Societies Building, 33 West 39th Street, New York, N. Y., January 23–27, 1933, will convince most electrical engineers that more than the usual number of papers which are of wide interest will be presented. The technical program committee has used great care in the selection of papers which deal with problems most important to the electrical industry at the present time.

Inspection trips, presentation of the Edison Medal, and entertainment features for both men and women are being arranged by the various subcommittees and will be announced in the January 1933 issue of ELECTRICAL ENGINEERING. The chairmen of these subcommittees are: convention executive committee, C. R. Jones, Westinghouse Electric & Mfg. Co., New York, N. Y.; dinner-dance committee, C. R. Beardsley, Brooklyn Edison Co., Brooklyn, N. Y.; smoker committee, R. A. McClenahen, United Engineers & Constructors, Inc., Newark, N. J.; inspection trips committee, W. R. Smith, United Engineers & Constructors, Inc., Newark, N. J.; and the ladies' committee, Mrs. E. B. Meyer, South Orange, N. J.

TECHNICAL SESSIONS

Notwithstanding adverse business conditions the Institute offers its membership an unusual opportunity to hear and take part in the discussion of the most recent advances that have been made in a number of specialized fields of the electrical industry. Thirteen sessions in all have been scheduled during the 5 days of the convention. These sessions have been paralleled so that those which hold interests in common conflict the least with one another and yet related subjects have been grouped close together to permit members who cannot stay for the entire week of the convention to obtain the most that is of interest to them in a shorter interval of time.

Each of several timely sessions have evolved from the close cooperation and united efforts of more than one committee. The communication requirements of railroads will be presented by authors representing 5 well known carriers. This session is under the auspices of the committee on communication, assisted by transportation subcommittee; it should prove to be of particular interest to engineers in both the communication and transportation fields. In addition, there will be another session dealing entirely with transportation problems. One of the papers in this session will present valuable operating data on the Cleveland Union Terminal electrification. One of the electrical machinery sessions, the lightning session, and several papers in the instruments and measurements sessions are closely related. The first treats the problem of insulation coordination, the second deals with lightning and impulse voltage experience with insulators and wood construction, and the third presents the measurement of impulse voltages. The papers which in all probability will be presented in the above sessions, as well as the various other sessions, are listed herewith.

Tentative Technical Program

Monday, January 23

10:00 a.m.—Registration

2:00 p.m.—Opening of Convention

—(A) Automatic Stations

PIPE LINE PUMPING AND AUTOMATIC CONTROL, John Fies, Texas Power and Light Co.

*THE PRINCIPLE OF CONDENSER DISCHARGE APPLIED TO CENTRAL STATION CONTROL PROBLEMS, F. H. Gulliksen, Westinghouse Electric & Mfg. Co.

*PRINCIPLES OF THE DIRECT-SELECTION SYSTEM OF SUPERVISORY CONTROL, M. E. Reagan, Westinghouse Electric & Mfg. Co.

*OPERATING EXPERIENCE WITH AUTOMATIC AND SUPERVISORY CONTROL, J. A. Noertker, The Cincinnati Street Railway Co.

2:00 p.m.—(B) Electric Welding

*†PRELIMINARY REPORT OF RESEARCH WORK DEALING WITH NOTTINGHAM'S EQUATIONS AND THE BOILING POINTS OF ANODES IN RELATION TO THE ANODE DROP IN POTENTIAL, J. L. Myer, Lehigh University.

*A NATURAL ARC WELDING GENERATOR, G. A. Johnstone, Great Lakes Electric Mfg. Co., Chicago, Ill.

*TRANSIENTS IN ARC WELDING GENERATORS, A. R. Miller, Lehigh University.

*HIGH VELOCITY VAPOR STREAM IN THE VACUUM ARC, R. C. Mason, Westinghouse Electric & Mfg. Co.

*PERFORMANCE AND DESIGN OF ELECTRIC WELDERS WITH CONTROLLED TRANSIENTS, F. Creedy, Lehigh University.

Tuesday, January 24

10:00 a.m.—(C) Communication

COMMUNICATION REQUIREMENTS OF RAILROADS, J. L. Niesse, New York Central Railroad Co., and R. C. Thayer, Great Northern Railway Co.

COMMUNICATION SYSTEM ON THE PENNSYLVANIA RAILROAD, I. C. Forshee, Pennsylvania Railroad.

RAILROAD SIGNALING AND TRAIN CONTROL, R. B. Amsden and W. M. Vandersluis, Illinois Central Railroad.

MODERN SIGNALING ON THE READING RAILROAD, E. W. Reich and G. I. Wright, Reading Co.

CENTRALIZED TRAFFIC CONTROL AND TRAIN CONTROL OF THE BALTIMORE AND OHIO RAILROAD, J. H. Davis and G. H. Dryden, Baltimore and Ohio Railroad.

10:00 a.m.—(D) Rotating Electrical Machinery

LOW-FREQUENCY SELF-EXCITING COMMUTATOR GENERATOR, J. I. Hull, General Electric Co.

SOME FACTORS AFFECTING TEMPERATURE RISE IN ARMATURES OF ELECTRICAL MACHINES, C. J. Fechheimer, Consulting Engineer.

PARALLEL OPERATION OF A-C GENERATORS—ACTION OF GOVERNORS AND DAMPER WINDINGS, M. Stone, Westinghouse Electric & Mfg. Co.

SYNCHRONOUS MOTOR PULLING-INTO-STEP PHENOMENA, H. E. Edgerton, Massachusetts Institute of Technology.

TWO-REACTION THEORY OF SYNCHRONOUS MACHINES—PART II, R. H. Park, Calco Chemical Co.

2:00 p.m.—(E) Transportation

*APPLICATION OF AIR CONDITIONING TO RAILROAD PASSENGER CARS, W. C. Goodwin and Charles Kerr, Jr., Westinghouse Electric & Mfg. Co.

*CALCULATION OF SINGLE PHASE SERIES MOTOR CONTROL CHARACTERISTICS, H. G. Moore and C. J. Axtell, General Electric Co.

*OPERATING DATA ON THE CLEVELAND UNION TERMINAL ELECTRIFICATION, F. H. Craton, General Electric Co.

POWER SUPPLY FOR MAIN LINE RAILWAY CONTACT SYSTEMS, P. A. McGee, Reading Railroad Co., and E. L. Harder, Westinghouse Electric & Mfg. Co.

SIMPLIFIED SPEED CONTROL FOR SINGLE PHASE LOCOMOTIVES, W. A. Giger, Allis Chalmers Mfg. Co.

Wednesday, January 25

10:00 a.m.—(F) Education

ADDRESS—THE PROFESSIONAL DEVELOPMENT OF THE ENGINEER, R. I. Rees, American Telephone & Telegraph Co.

10:00 a.m.—(G) Insulation Coordination

*PROGRESS REPORT ON IMPULSE TESTING OF COMMERCIAL TRANSFORMERS, F. J. Vogel, Westinghouse Electric & Mfg. Co., and V. M. Montsinger, General Electric Co.

*FACTORS INFLUENCING THE INSULATION COORDINATION OF TRANSFORMERS, F. J. Vogel, Westinghouse Electric & Mfg. Co.

*COORDINATION OF INSULATION, V. M. Montsinger, W. L. Lloyd, Jr., and J. E. Clem, General Electric Co.

*RECENT DEVELOPMENTS IN HIGH-CURRENT MERCURY-ARC RECTIFIERS, E. H. Reid and C. C. Herskind, General Electric Co.

* SYNCHRONOUS-MECHANICAL RECTIFIER-INVERTER, S. S. Seyfert, Lehigh University.

Thursday, January 26

10:00 a.m.—(H) Lightning

*IMPULSE TESTING RECOMMENDATIONS, SUBCOMMITTEE ON LIGHTNING AND INSULATORS, Philip Sporn, Chairman.

*Lightning Investigation on Transmission Lines—III, W. W. Lewis and C. M. Foust, General Electric Co.

*Lightning Experience on 132-Kv Lines of the American Gas and Electric Company System, Philip Sporn, American Gas and Electric Co.

*Impulse and Dynamic Flashover Studies of 26-Kv Wood Pole Transmission Construction, A. S. Brookes and R. N. Southgate, Public Service Electric & Gas Co., and E. R. Whitehead, Westinghouse Electric & Mfg. Co.

*Operating Experience With Wood Utilized As Lightning Insulation, H. L. Melvin, Electric Bond and Share Co.

10:00 a.m.—(I) Electrochemistry and Electrometallurgy

Address—Increasing Applications of Electricity to Chemical Processes, Colin G. Fink, Columbia University.

*Light Sensitive Industrial Process Control, J. V. Alfriend, Jr., Westinghouse Electric & Mfg. Co.

2:00 p.m.—(J) Instruments and Measurements

A Standard of Low Power Factor, W. B. Kouwenhoven and L. J. Berberich, The Johns Hopkins University.

A Bridge for Precision Power Factor Measurements on Small Oil Samples, J. C. Balsbaugh and P. H. Moon, Massachusetts Institute of Technology.

Skin Effect in Rectangular Conductors—A Method of Measurement and Experimental Data, H. C. Forbes and L. J. Gorman, The New York Edison Co.

*Impulse Voltage Testing, C. F. Harding and C. S. Sprague, Purdue University.

*The Measurement of High Surge Voltages, P. L. Bellaschi, Westinghouse Electric and Mfg. Co.

*Laboratory Measurement of Impulse Voltages, J. C. Dowell and C. M. Foust, General Electric Co.

2:00 p.m.—(K) Industrial Applications

*Circuit Breaker Protection for Industrial Circuits, H. J. Lingal and O. S. Jennings, Westinghouse Electric & Mfg. Co.

*Variable Voltage Equipment for Oil Well Drilling, A. H. Albrecht, Standard Oil Co. of Calif.

*Recent Developments in Electronic Devices for Industrial Control, F. H. Gulliksen, Westinghouse Electric & Mfg. Co.

Friday, January 27

10:00 a.m.—(L) Protective Devices

The Use of Communication Facilities in Transmission Line Relayng, J. H. Neher, Philadelphia Electric Co.

Protection of Electrical Apparatus—Recommended Practise, Relay Subcommittee, O. C. Traver, Chairman.

A Sequence Relay for Network Protectors, H. S. Orcutt, United Electric Light and Power Co., and M. A. Bostwick, Westinghouse Electric & Mfg. Co.

Phase Sequence Relaying, H. R. Searing, The New York Edison Company and The United Electric Light & Power Co., and R. E. Powers, Westinghouse Electric & Mfg. Co.

10:00 a.m.—(M) Selected Subjects

Higher Steam Pressures and Temperatures—A Challenge to Engineers, M. D. Engle and I. E. Moultrop, The Edison Electric Illuminating Co. of Boston.

*Actions Taken by the Symbols, Units, and Nomenclature Committee of the International Union of Pure and Applied Physics, A. E. Kennelly, Harvard University.

Empirical Equations for the Magnetization Curve, J. P. Barton, Milwaukee, Wis.

†Tensor Analysis of Rotating Machinery, Gabriel Kron, United Research Corp.

2:00 p.m.—(N) Research and Applied Electronics

The Dielectric Losses in Impregnated Paper, J. B. Whitehead, The Johns Hopkins University.

Applications of Harmonic Commutation for Thyratron Converters, C. H. Willis, Princeton University.

*Ignition of Arcs in Vapor Discharge Tubes, J. Slepian and L. R. Ludwig, Westinghouse Electric & Mfg. Co.

*Capacitance and Loss Variations With Frequency and Temperature in Composite Insulation, H. H. Race, General Electric Co.

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* These papers are under consideration for presentation at the winter convention, but up to date of going to press have not been officially placed upon the program.

† These papers will not be published in advance form by the Institute but copies may be made available by the respective authors.

Rules on Presenting and Discussing Papers

At the technical sessions papers will be presented in abstract, 10 min being allowed for each paper unless otherwise arranged, or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually 5 min are allowed each discusser. When a member signifies a desire to discuss papers on other subjects or groups, he shall be permitted a 5-min period for each subject or group.

It is preferable that a member who wishes to discuss a paper give his name beforehand to the presiding officer of the session at which the paper is to be presented. Copies of discussion prepared in advance should be left with the presiding officer. Each discusser is to step to the front of the room and announce, so that all may hear, his name and professional affiliations. Discussions at the technical sessions are not reported. To be considered for publication, discussions should be written and mailed to the A.I.E.E., Editorial Department, 33 West 39th Street, New York, N. Y., on or before Feb. 10, 1933.

Electric Railway Association Changes Name.—At the Annual Business Meeting of the American Electric Railway Association held in Chicago, Illinois, the last week in September 1932, the name of this association was changed to the American Transit Association. It is felt that the new name more accurately indicates the scope of the association's functions and activities and its interest in the transportation business. The change in name has been under consideration for several years. To be consistent with the name of the parent association, the names of the 4 affiliated associations were also changed at that time and are now the American Transit Accountants' Association, American Transit Claims Association, American Transit Engineering Association and American Transit Operating Association.

Utah Section Offers Prizes for Papers

Prizes amounting to $25 have been offered by the Utah Section for papers presented before that Section by its members, according to announcement at the Section's October 10, 1932, meeting in Salt Lake City, by Dr. J. H. Hamilton, chairman of the Section's program committee. Excerpts from the announcement follow:

"To encourage members of the Utah A.I.E.E. Section to present papers before the local Section the executive committee has voted $25 for prize awards. . . . . first prize $15, second prize $10. Papers are to be judged by 3 judges appointed by the executive committee, and prizes will be awarded at the final meeting of the Section. To facilitate the management, the following rules have been established:

1. "The contest is open to an Institute member of any grade and to any person whose application for membership is in process. Application for admission to the contest is to be made to the Section secretary before November 15, 1932, ... [stating] a tentative title of the paper, the approximate length, and the choice as to date of delivery."

2. "The valuation governing the grading of the Section papers in determining the prize award will be identical with those used by the national committee in determining the award of national prizes."

Student Conference Held by South West District

A Student conference of the Institute's South West District, No. 7, was held October 21 and 22, 1932, at the University of Oklahoma, Norman. In addition to the 4 members of the faculty and 50 junior and senior students from the University of Oklahoma, there were present 106 from other colleges and the Oklahoma City Section. Attendance of the chairmen and counselors, as shown in Table I, was exceptionally good. The absence of the 3 counselors who were not present was unavoidable.

Two meetings of the Branch counselors and Student chairmen were held. Considerable discussion was centered on the present practise in this District of awarding prizes for student papers other than the Institute's usual national and District prizes for Branch papers. It was felt that an element of unfairness resulted from the fact that some of the colleges in the District required undergraduate research and theses, whereas others had no such requirements. In order to obviate this difficulty a motion was passed to the effect that although technical sessions would be held at future meetings, papers by students of the various Branches would not be put in competition, ranked, or prizes offered for the best paper. Other problems discussed at these meetings included means for increasing attendance, improving interest and making the Student Branch more as an introduction to membership in the Institute after graduation.

Three technical sessions were held, at which 10 Student papers were presented. The paper entitled, "The Development of a Medium Priced High Quality Microphone," by J. D. Martin, Jr., of the Missouri School of Mines and Metallurgy, was decided to be the best paper presented at this session, and his Branch was awarded the bronze plaque offered this year by the Oklahoma City Section. The other Student papers presented were as follows:

Construction of WNAD, by Wilmer Ragsdale and Bryan Cole, Okla. Univ.

Recent Developments in the Metering of Electrical Energy, by M. P. Jones, Southern Methodist Univ.

Transmitters for Broadcast Service, by R. D. Compton, Kansas State Col.

Some Fundamentals of Inductive Coordination, by David Sussin, Texas Univ.

Influence of Voltage Variations on Induction Motor Characteristics, by L. C. Wasson, Arkansas Univ.

Economics of Rural Line Distribution, by B. E. Lowe, Okla. A. & M. Col.

A Device for Demonstrating Symmetrical Components, by Stanley Fish and Austin True, Univ. of New Mexico.

An Ultra Short Wave Transmitter, by G. C. Hutcheson, Texas A. & M. Col.

Comparison of Strowger Type With Panel Type Automatic Telephone Equipment, by R. C. Jackson and L. D. Weiser, Univ. of Kansas.

Table I—Counselors and Chairmen Present

College	Branch Counselor	Student Chairman
University of Arkansas	W. B. Stelzner	L. C. Wasson
Kansas State College	R. G. Kloeffler	G. D. Ferguson (v-chm.)
University of Kansas	D. C. Jackson, Jr	R. C. Jackson
Missouri School of Mines	I. H. Lovett	J. D. Martin
University of Missouri	M. P. Weinbach	A. L. Coffman
University of New Mexico		Stanley Fish
Oklahoma A. & M. College	A. Naeter	J. R. Hollis
University of Oklahoma	F. G. Tappan	H. H. Moody
Rice Institute	J. S. Waters	E. F. Kinzer
Southern Methodist University	H. F. Huffman	R. P. Lindsley
A. & M. College of Texas	H. C. Dillingham	G. H. Samuels
Texas Technological College		Preston Conner
University of Texas	J. A. Correll	F. C. Sperry
Washington University		C. E. Keiser

Changes Made in A.I.E.E. Prizes for Technical Papers

AUTHORS who plan to present papers before the Institute during the calendar year 1933, those who have presented papers during 1932, and others who may wish to submit papers for prizes, would do well to bear in mind that such papers are eligible for consideration for Institute prizes. These awards are made each spring for the preceding calendar year, and fall into 2 main classes, national and District prizes.

On account of the reduced income of the Institute, the board of directors decided to omit the cash awards for papers presented during the calendar year 1932, except that a payment of $25 in cash will accompany each District Prize for Branch Paper. All certificates will be issued as usual, those for national prizes signed by Institute officers, and those for District prizes signed by the officers of the Districts concerned. In cases of joint authorship, a certificate will be issued to each author.

National Prizes

The national prizes which may be awarded at the discretion of the committee on award of Institute prizes are as follows:

1. Prizes for best papers in (1) *engineering practise*, (2) *theory and research*, and (3) *public relations and education*.
2. Prize for initial paper.
3. Prize for Branch paper.

The national prize for best paper in each of the 3 classes indicated may be awarded to the author or authors of the best original paper presented at any national, District, or Section meeting of the Institute, provided the author, or at least one of coauthors, is a member of the Institute.

The national prize for initial paper may be awarded to the author or authors of the most worthy paper presented at any national, District, Section, or Branch meeting of the Institute, provided the author or authors have never previously presented a paper which has been accepted by the technical program committee, and the author, or at least one of coauthors, is a member of the Institute or is a graduate student enrolled as a Student of the Institute.

The national prize for Branch paper may be awarded to the author or authors of the best paper based upon undergraduate work presented at a Branch or other Student meeting of the Institute, provided the author or authors are Student Branch members.

All papers approved by the technical program committee which are presented at any meeting will be considered by the committee on award for the prizes for best paper and initial paper without being formally offered for competition. All papers other than those presented to the technical program committee must, in order to receive consideration, be submitted in triplicate with a written communication to the national secretary on or before February 15 of the year following the calendar year in which they were presented. This may be done by the author or authors, by an officer of the Institute, or by the executive committees of Sections, or Geographical Districts.

District Prizes

The following District prizes may be awarded each year in each Geographical District of the Institute.

1. Prize for best paper.
2. Prize for initial paper.
3. Prize for Branch paper.

A District prize may be awarded only to an author who, or to coauthors of whom at least one, is located within the District, and for a paper presented at a meeting held within, or under the auspices of, the District.

The District prize for best paper may be awarded for the best paper presented at a national, District, or Section meeting, provided the author, or at least one of coauthors, is a member of the Institute.

The District prize for initial paper may be awarded for the best paper presented at a national, District, Section, or Branch meeting, provided the author or authors have never before presented a paper before a national, District, or Section meeting of the Institute, and the author, or at least one of coauthors, is a member of the Institute or a Graduate student enrolled as a Student of the Institute.

The District prize for Branch paper may be awarded for the best paper based upon undergraduate work presented at a Branch or other Student meeting of the Institute, the author or authors of which are Student Branch members.

All papers to be considered in competition for District prizes must be submitted in duplicate by the authors or by the officers of the Branch, Section, or District concerned to the District committee on awards on or before January 10 of the year following the calendar year in which the papers have been presented.

Copies of a pamphlet entitled "National and District Prizes" may be secured, without charge, upon application to Institute headquarters.

Dr. Langmuir Awarded Nobel Prize in Chemistry

The Nobel Prize in chemistry for 1932 has been awarded to Dr. Irving Langmuir, associate director of the research laboratory of the General Electric Company, Schenectady, N. Y. The award will be presented to him in Stockholm, Sweden, on December 10, 1932.

Dr. Langmuir was born in Brooklyn, N. Y., 1881. He graduated from the School of Mines of Columbia University in 1903 and received his master's degree and that of doctor of philosophy from the University of Goettingen, Germany. Honorary degrees have since been awarded him by several institutions. Between 1906 and 1909 he was instructor in chemistry at the

Stevens Institute of Technology, Hoboken, N. J., and since 1909 has been connected with the research laboratory of the General Electric Company.

One of Dr. Langmuir's early achievements was the development of the high intensity incandescent lamp, the bulb of which contained small quantities of either nitrogen or argon. It has been stated that the cost of energy required for electric lighting in this country has been reduced about 50 per cent by this gas filled lamp. Growing out of this work with the incandescent lamp were important discoveries in the field of the vacuum tube. The vast development of radio broadcasting and the use of the vacuum tube in electrical control operations and similar fields can be traced largely to Dr. Langmuir's discoveries. His discovery of the atomic hydrogen method of electric welding also was of great importance, as this permits the welding of metals which formerly could not be joined. His many published papers are considered by scientists to be of considerable value. Dr. Langmuir has been particularly interested in the mechanism of chemical reactions taking place on solid surfaces and is now working out the laws according to which atoms and molecules distribute themselves over surfaces, forming single layers of atoms. These laws are of importance in understanding many simple phenomena, such as those of the spreading of oil films on water and of lubrication.

Dr. Langmuir has received many previous honors. The Nichols Medal was awarded to him by the New York Section of the American Chemical Society, first in 1915 for his work on chemical reactions at low pressures, and again in 1924 for his work on atomic structure. In 1918 he received the Hughes Medal from the Royal Society of London in recognition of his researches in molecular physics. The Rumford Medal was awarded him in 1920 by the American Academy of Arts and Sciences for the thermionic researches and his gas filled incandescent lamp. The Royal Academy of Lincei, Rome, Italy, presented its Cannizaro Prize to him in 1925; he received the Perkins Medal in 1928 and the Chandler Medal in 1930. Earlier this year *Popular Science Monthly* awarded him its annual medal and honorarium of $10,000. Dr. Langmuir is a past-president of the American Chemical Society and is a member of many scientific organizations.

So. Calif. Edison Names New Executives

According to news dispatches under date of October 19, the board of directors of the Southern California Edison Company, Ltd., Los Angeles, has named G. C. Ward (M'24) as its president and H. J. Bauer as chairman of the Board.

These new officers will fill vacancies caused by the death in April 1932 of the company's former board chairman, J. B. Miller, and in August of its former president, R. H. Ballard. Mr. Bauer has been an Edison director for some time; Mr. Ward has been a company official for many years.

Data Concerning Appropriations for the 60 Local Sections of the Institute for the Appropriation Year Ending September 30, 1932

	Section Membership as of Aug. 1, 1931	Section Appropriations as of Aug. 1, 1931, as Provided by the Bylaws	Net Amounts Paid to Sections in Accordance With Agreements	Net Savings From Normal Appropriations	Percentages of Normal Appropriations Saved
1. Sections that did not indicate acceptance of 10% deduction, but which nevertheless show expenditures of less than the annual appropriation					
Connecticut	263	$ 438.00	$ 264.77	$ 173.23	39.5
Iowa	62	237.00	98.49	138.51	58.4
Lehigh Valley	271	446.00	420.37	25.63	5.0
Nebraska	55	230.00	59.72	170.28	74.0
New York	3,794	4,215.67	4,011.23	204.44	4.8
Urbana	36	211.00	50.76	160.24	76.0
Worcester	61	236.00	141.00	95.00	40.0
2. Sections that have accepted 10% deduction of normal appropriation but have not yet rendered final report of expenditures for year ending September 30, 1932 (thus indicating a possible additional saving)					
Houston	71	246.00	*221.40	*24.60	*10.0
Lynn	134	309.00	*278.10	*30.90	*10.0
Madison	55	230.00	*207.00	*23.00	*10.0
Seattle	218	393.00	*353.70	*39.30	*10.0
3. Sections that did not accept 10% deduction and expended full appropriation					
Mexico	94	269.00	269.00	0.0	0.0
Milwaukee	221	396.00	396.00	0.0	0.0
Providence	80	255.00	255.00	0.0	0.0
Rochester	103	278.00	278.00	0.0	0.0
4. Sections that did accept a deduction of 10% or more from normal appropriation					
Akron	75	250.00	225.00	25.00	10.0
Atlanta	102	277.00	249.30	27.70	10.0
Baltimore	217	392.00	352.80	39.20	10.0
Boston	513	688.00	619.20	68.80	10.0
Chicago	1,098	1,273.00	1,145.70	127.30	10.0
Cincinnati	168	343.00	308.70	34.30	10.0
Cleveland	274	449.00	404.10	44.90	10.0
Columbus	62	237.00	213.30	23.70	10.0
Dallas	114	289.00	260.10	28.90	10.0
Denver	154	329.00	296.10	32.90	10.0
Detroit-Ann Arbor	310	485.00	436.50	48.50	10.0
Erie	99	274.00	246.60	27.40	10.0
Fort Wayne	80	255.00	196.70	58.30	22.8
Florida	42	217.00	108.45	108.55	50.0
Indianapolis-Lafayette	88	263.00	236.70	26.30	10.0
Ithaca	38	213.00	191.70	21.30	10.0
Kansas City	158	333.00	299.70	33.30	10.0
Los Angeles	477	652.00	576.45	75.55	11.5
Louisville	53	228.00	205.20	22.80	10.0
Memphis	53	228.00	205.20	22.80	10.0
Minnesota	96	271.00	243.90	27.10	10.0
Montana	26	201.00	170.59	30.41	15.0
Niagara Frontier	176	351.00	315.90	35.10	10.0
North Carolina	83	258.00	89.89	168.11	65.0
Oklahoma City	64	239.00	215.10	23.90	10.0
Philadelphia	760	935.00	841.50	93.50	10.0
Pittsburgh	724	899.00	809.10	89.90	10.0
Pittsfield	137	312.00	280.80	31.20	10.0
Portland	121	296.00	266.40	29.60	10.0
St. Louis	256	431.00	374.83	56.17	13.0
San Antonio	65	240.00	216.00	24.00	10.0
San Francisco	460	635.00	571.50	63.50	10.0
Saskatchewan	39	214.00	192.60	21.40	10.0
Schenectady	456	631.00	567.90	63.10	10.0
Sharon	111	286.00	257.40	28.60	10.0
Southern Virginia	85	260.00	216.67	43.33	16.0
Spokane	46	221.00	198.00	22.10	10.0
Springfield	99	274.00	137.00	137.00	50.0
Syracuse	68	243.00	218.70	24.30	10.0
Toledo	87	262.00	217.21	44.79	17.0
Toronto	388	563.00	402.06	160.94	28.0
Utah	58	233.00	209.70	23.30	10.0
Vancouver	91	266.00	239.40	26.60	10.0
Washington	183	358.00	322.20	35.80	10.0
5. Section Inactive During the Year 1931–32					
Birmingham					
Total Sections—60		24,943.67	*21,656.39	*3,286.38	*13.2%

* Tentative figures pending receipt of reports from Sections listed in Item 2.

55 Sections Have Assisted in Meeting Reduced 1931–32 Budget

BECAUSE of the reduced income of the Institute, the board of directors at its meeting held on October 23, 1931, adopted a budget of proposed expenditures for the year 1931–2 materially lower than normal, and invited the Sections to cooperate with the board by keeping their expenditures at least 10 per cent below the amounts which would have been available under the provisions given in the bylaws. The board of directors requested that a statement be published after the close of the year giving full credit to all Sections for their cooperation and showing the percentage of reduction attained by each. This information is given in the accompanying tabulation.

The splendid cooperation extended by a large majority of the Sections is sincerely appreciated and has been of great assistance in the efforts to reduce Institute expenditures wherever practicable without interfering seriously with any of the activities.

Summarized Review of Baltimore Meeting Discussions

PRINCIPAL discussions of the Baltimore Meeting papers are summarized herewith. The papers to which these discussions refer were abstracted in ELECTRICAL ENGINEERING for September 1932, p. 659–62. Only discussion submitted in writing in accordance with governing A.I.E.E. rules is summarized. Complete discussion, together with all approved papers, will be published in the TRANSACTIONS.

POWER CABLES

R. J. Wieseman (Passaic, N. J.) discussed the historical background of submarine cable installation leading up to the 115 kv Columbia River crossing. He felt that these recent installations of long-length high-voltage cables should be a source of comfort and encouragement to the utilities in solving their future transmission problems. Cable manufacturers have eliminated the cable as the "neck in the bottle" of best design of large, high voltage power transmission system.

Thermal Transients and Oil Demands.—F. H. Buller (Schenectady, N. Y.) in his discussion of this subject expressed the belief that all who have occasion to make temperature-transient or oil-demand calculations on cables are indebted to the authors for the simplifications which they have devised to render computations less laborious. The discusser had found charts 1 and 2 of the paper useful in obtaining approximate values of the roots of equation 6. He believed their limitations were in the mechanics of reproduction rather than in the underlying theory. The method of evaluating the coefficient c_n described by the authors was believed to be simple in theory and usually useful in practise, particularly if only 3 terms of the infinite series for temperature and oil demand are required. He suggested a mathematical solution and presented equations for use in cumbersome cases where more than 3 terms are required.

E. A. Church (Boston, Mass.) also discussed this subject. One of the important facts that he emphasized was that the temperature and oil demand equations for load suddenly applied (unit function in Heaviside terminology) are functions of the constants of the cable only. A graphical method was described that facilitated evaluation of the integral and overcomes the practical difficulties encountered in solving for the coefficients and exponents of each term of the series.

Another discussion by R. J. Wieseman expressed appreciation for the completeness of the analysis of this subject and the excellent charts developed to simplify the labor of making calculations of thermal transients or oil demands. Researches have shown internal pressures in solid cable to be much higher than realized. High pressures have been formed at the conductor and sheath without indication of a positive pressure in the middle of the insulation. This has not been fully understood, but Mr. Wieseman believed that a mathematical analysis along the lines of this paper might offer an explanation.

Traveling Wave Voltages.—L. V. Bewley (Pittsfield, Mass.) in discussing this paper expressed the belief that, when taken in conjunction with an earlier paper dealing with the experimental work, it formed a comprehensive treatment of the problem. He suggested and illustrated with equations several ways for increasing the generality of the paper.

J. E. Clem (Schenectady, N. Y.) discussed this subject and analyzed the voltages set up in a cable at the end of a transmission line by the impact of a traveling wave. Calculations were made in two ways: one on the basis of lumped capacitance, the other taking into account the distributed constants of a cable. A comparison of these calculations and a comparison with the test results indicated that the need of cable protection can be determined by calculations made on the basis of lumped capacitance. It was recommended that any cable installation less than 4,000 ft in length be checked to determine the possible need of protection. If the cable at the exit end is connected to a transformer, or a very high surge impedance, protection should be applied.

TELEPHONE CABLES

Electrical Testing in Wire Plants.—W. A. Del Mar (Yonkers, N. Y.) in discussing this subject described some of the early methods of testing in electric wire manufacture and advocated the use of high frequency alternating current. He asked the authors why a frequency of a few hundred cycles was used when by the use of higher frequencies shock hazard could be avoided, a spark of greater searching ability obtained, and the necessity of grounding the wire avoided. He regarded the high frequency spark as especially useful in finding "pinholes" or other air openings in the insulation, but not reliable as a test for the dielectric strength of a patch.

Another discusser, R. J. Wieseman (Passaic, N. J.) inquired as to the speed at which the wire travels through the testing outfit, the voltage and time values used in making the water test, and the limiting thickness of insulation that could be adequately tested by the spark method.

Pulp Insulation.—W. A. Del Mar (Yonkers, N. Y.) discussed this subject and inquired concerning the flexibility of this insulation when applied in layers as heavy as 50 mils or more. In regard to the authors' suggestion of new applications, he asked if any of these had materialized in the interim since the writing of the paper.

R. J. Wieseman (Passaic, N. J.) asked about the nature of the wood pulp now used, with special reference to the possible use of spruce fiber. He also asked if the method of insulating the conductors and assembling would result in a firmer cable. In regard to the antimony-lead sheaths of telephone cables, he inquired if pure lead had been considered for cases where the cable is drawn into ducts.

L. S. Ford (Kearny, N. J.) explained that pulp insulated wire fitted very well into the unit idea of cable layup. The construction has been standardized for 24-gage as well as 26-gage pulp cable and it is just being applied to 22-gage pulp cable. Pulp has not as yet resulted in a new line of cable, but in a new type of an existing series of Nos. 24 and 26 exchange area cables that are lower in first cost and that compare very well in quality with the ribbon-insulated cables which they displace. He predicted that in the future, advantage will be taken of the considerable range of values in weight and diameter admitted by pulp.

Use of Cables for Telephone Distribution Purposes.—J. A. Cadwaller (Pittsburgh, Pa.) discussed this subject and described a buried cable distribution system recently installed in a high class residential development near Pittsburgh. The land company reserved a 10-ft strip along the rear property line for the utilities, provided trenches for the cables and excavations for the splicing boxes. Conduits from the houses to the nearest splicing boxes were provided by the individual property owners. The telephone company furnished and installed tape armored distribution cable, splicing boxes, terminals, and 1- or 2-pair lead covered cable from the splicing boxes to the houses. The entire cost of this distribution system to the telephone company closely approxi-

mated the estimated cost of an aerial cable job on jointly occupied poles.

L. F. Cromwell in his discussion in connection with this subject emphasized the importance of careful cable-pair multiplying in the design of the cable plant so as to effect a minimum plant investment and minimum annual charges consistent with good service. The real test, he thought, is not encountered when the installation is first completed, but rather when service has increased to such an extent that the cable had a majority of its pairs in use.

Another discussion by C. L. Garrett gave consideration to factors which may tend to reduce the intelligibility of speech reception such as noise, crosstalk, and distortion. He pointed out that these factors must be considered and allowance made for them in the design of the plant.

Economic Aspects of Water Power

A. E. Bauhan (Newark, N. J.) stated that the paper on this subject treated the relative economies of water and steam power in a thorough and sound manner. One of the points brought out in this discussion was in connection with the introduction of the time element, which brings with it the uncertainties of future loads and future competitive plant costs. The curves in the paper, plotted on the basis of percentage of capacity installed, may show a hydroelectric cost, after the initial development, materially below the hydroelectric value and one must not draw from them the conclusion that the project is economically justified. The discusser suggested going a step further and plotting hydroelectric costs and hydroelectric value against years.

William McClellan (New York, N. Y.) pointed out some of the merits of the same paper. He recommended the reading of the paper by every young engineer, not only for the immediate subject of the discussion, but also for the method the author used which, he said, gives a comprehensive treatment of a most intricate subject.

R. E. B. Sharp (Philadelphia, Pa.) in his discussion of the paper considered the performance obtained by the dual operation of pumps and turbines. He considered the case of the design of a centrifugal pump provided with short vanes having a large angle between these vanes (at discharge) and the tangential. When operating as a pump the losses due to diffusion, caused by too great an angle between the vanes, and consequently too great a rate of area expansion, would result in relatively low efficiency as a pump. However, the steep vane angle and short passages would tend to give relatively high efficiency as a turbine. He thought that there was no basis for the efficiency of any centrifugal pump necessarily being the same when operating as a pump as when operating as a turbine.

J. E. Stewart (Pittsburgh, Pa.) considered that the paper clearly brought out the modern conception that the main value of the utility hydroelectric plant, where there is not a high minimum stream flow, was its capacity. He felt that, unless the flow at hydroelectric stations was backed by natural storage or relatively low cost artificial storage, energy costs for hydroelectric plants usually could not compete with energy from modern steam stations.

Another discussion by Ireal A. Winter (Birmingham, Ala.) called attention to the value of this paper, particularly the part dealing with hydroelectric regeneration equipment. He believed the time is fast approaching when the conception of a wide use of hydroelectric regeneration will mature into a concrete fact.

Safe Harbor Project

J. R. Baker (Baltimore, Md.) in his discussion of this subject drew attention to the progress in hydroelectric design that has occurred in recent years. A comparison of this plant with the Holtwood plant designed some 20 years earlier showed a striking economy of building volume in the design of the Safe Harbor plant. By more skillful arrangement the building mass and structure also were applied to better purpose. The great advance in hydraulic design was well illustrated by the fact that the controlled water path through the Safe Harbor plant, not withstanding its smaller dimensions, is twice as long horizontally as that in the Holtwood plant.

F. H. Hollister (Chicago, Ill.) in connection with this subject cited the advantage of flat efficiency curves and the advances made in steam turbine and boiler room efficiencies during the last 10 years. He believed that this has made imperative the improvement of the over-all all-day efficiency of the hydroelectric station or else greatly reduce the investment permissible in a low head hydroelectric plant. He also referred to the wisdom of making provisions for automatic bus protection.

A. H. Hull (Toronto, Canada) discussed several features about the development, in order to bring out at greater length some of the considerations that led to the construction adopted. He was impressed with the thorough manner in which the many design problems had been handled, and with the result of a superstructure of pleasing appearance that permitted a compact arrangement of major equipment.

Another discussion by A. B. Lakey (Philadelphia, Pa.) described the construction of the 82-in. pivoted-segment thrust bearings for the Safe Harbor units. These thrust bearings carry a load up to about 750 tons apiece with a resulting unit pressure of 416 lb per sq in. on the 3,600 sq in. net of babbitted bearing-shoe surface. The novelty of the design consists mainly in the ease of vertical adjustment at any time, and in the minimum disturbance of other parts of the unit incidental to inspecting or changing the bearing surfaces.

C. F. Merriam (Baltimore, Md.) described the Safe Harbor governing system, which in many respects represents a distinct advance in power plant design. Operation of the turbines has been concentrated on a single floor by locating pumps and actuators on the same level, with a resultant saving in personnel. The twin system located in the space between the two units of each pair eliminates long lines of piping. The protective devices and annunciator system also were described. Impulses from the respective relays not only indicate the source of trouble, but also act upon certain safety devices arranged to produce the desired effect upon the governor.

J. E. Stewart (Pittsburgh, Pa.) in his discussion of this subject expressed a belief that the outstanding feature of the Safe Harbor development was the engineering study that had been devoted to it, and the fact that so many of the results of these studies were incorporated in the actual construction.

Another discussion by R. L. Thomas (Baltimore, Md.) interestingly revealed the history of this development from the time of the first individual flow rights, which dated back to 1902, up through the selection and acquisition of the present site. Early economic studies by the regular operating staff without any publicity and without outside aid prior to making of core borings at the dam site resulted in relatively low costs of property and flow rights as well as for preliminary engineering and organization work. The pre-license cost, exclusive of property, amounted to less than one per cent.

In addition to the foregoing discussion of this development, P. M. Hess, station superintendent at Safe Harbor, outlined the operating experience with the major pieces of equipment thus far obtained from the 10 months' period operation.

Safe Harbor-Westport 230-Kv Transmission Line.—H. S. Phelps (Philadelphia, Pa.) in his discussion made a comparison between this line and the Philadelphia Electric Company's 220-kv lines which have essentially the same electrical design features. He presented operating data on the latter lines and suggested a comparison of operating results between these lines. He believed such a comparison should make possible the forming of conclusions better than those presently held concerning the influence on line performance of insulator spacing and string length, size and location of ground wires, and phase wire spacing.

C. L. Fortescue (East Pittsburgh, Pa.) discussed the early considerations that entered into the design of this line. He explained that in the design of transmission lines a compromise must be made between what can be done regardless of cost and what can be considered as economically justified. He believed the author had effectively reached such a compromise as indicated by the performance during the past year.

Safe Harbor Kaplan Turbines.—E. Brown (Montreal, Canada) discussed this subject and raised questions concerning several points about the paper. One of these concerned the curves in Fig. 6 which he believed showed large differences between the values of Σ at which the efficiency begins to decrease and the unit quantity to increase. He believed that the points of increase or decrease were not well defined. The authors' statement that "the value of Σ, at which efficiency and discharge were found to break, was taken as the cavitation limit for that particular speed, head, and gate opening" seemed to the discusser to imply a much closer agreement between Σ values than that shown in Fig. 6.

In connection with the cavitation experiments, J. A. Peck (Boston, Mass.) asked what means were employed to isolate the phenomenon of the efficiency break so that it could be positively attributable

to the cavitation rather than to some other coincidental factor, such as a crisis in the flow conditions within the particular type of draft tube in use.

R. E. B. Sharp (Philadelphia, Pa.) discussed the cavitation problem and referred to an installation in Canada that furnishes an interesting example of the ability of a turbine to operate without serious pitting with a value of Σ so low as to result undoubtedly in the formation of continuous cavitation without sufficient pressure to cause the collapse of the cavities. A curve was presented which represented roughly the limit in value of Σ for the usual modern propeller runner designs.

Messrs. L. B. Stirling and J. B. MacPhail (Montreal, Canada) asked if the possible occurrence of pitting in the draft tube was examined by paint tests. The pitting of a painted surface in a model draft tube is believed to be a good indicator of erosion of concrete on the full sized installation. This relation has been proved to be correct in at least 2 cases.

Another discusser, H. S. Van Patter (Montreal, Canada) inquired, in connection with the tests, as to why it was considered necessary to hold the total head constant when varying the suction head and asked if that decision had been confirmed by test results. In other words had tests shown that the cavitation point was affected by variations in total head?

Low Head Hydroelectric Developments

L. F. Harza (Chicago, Ill.) in his discussion of this paper questioned the general desirability of using special Kaplan wheels on horizontal shafts, such as shown in the author's Fig. 26. He pointed out that the draft tube problem is complicated, the building width greater, and that high tailwater requires design of the generator room walls for outside pressure, and the use of drainage pumps to remove leakage.

H. E. Popp (Boston, Mass.) discussed this subject from a point of view different from that taken by the author. He did not agree that credit for past accomplishment in the field of economical low head developments was due entirely to European engineers. It was pointed out that the so-called Kaplan turbine in reality is the use of the adjustable-blade runner and its control mechanism in combination with the usual form of scroll case, draft tube, and miscellaneous mechanical details independently developed and perfected by American engineers. He also believed that there was grave danger that overemphasis of some particular phase of design, such as the cavitation problem, might lead to the introduction of costly practises that are not justified by the ends obtained. In this connection he did not agree with the practise to machine and polish all runner blade surfaces in contact with flowing water, especially since this has no effect on efficiency.

J. W. Rickey (Pittsburgh, Pa.) was of the opinion that the future development of hydroelectric projects of low and medium head in the United States depended upon obtaining lower plant cost through greater economy in the design of both plant and equipment. This, he believed, could be achieved only when the manufacturer and the user of turbines adopt a radically different attitude toward the scientific side of concurrent turbine design and laboratory tests.

F. H. Rogers (Philadelphia, Pa.) in his discussion presented considerable of the history of the development of the propeller turbine, in particular the achievements made in the United States. He referred to the Great Falls development of the Manitoba Power Company undertaken in 1921 when the Dominion Engineering Works, Ltd., proposed I. P. Morris propeller turbines of 28,000 hp unit capacity for a head of 56 ft. At that time a cavitation theory for the propeller turbine was developed utilizing data from marine propeller experience. He also referred to the early work of L. F. Moody, an American engineer, who first demonstrated that for a head range more than double that previously attempted, equal or greater efficiencies with freedom from cavitation could be secured by the use of large areas for the blades.

In connection with this subject R. V. Terry (Newport News, Va.) told of a new type of adjustable propeller turbine now in the process of development. The vanes of the runner are adjusted automatically by the water flow, assuming the most efficient angle for any head and for any load within the capacity of the turbine.

John Fritz Medal for 1933 Awarded

The John Fritz Gold Medal for 1933 has been awarded to Daniel Cowan Jackling for "notable industrial achievement in initiating mass production of copper for low grade ores through application of engineering principles." The award was made by a board of 16 representatives of the 4 national engineering societies.

Mr. Jackling is the twenty-ninth engineer to receive the John Fritz gold medal, which is awarded not oftener than once a year for notable scientific or industrial achievement without restriction on account of nationality or sex. It is a memorial to the late John Fritz, a leader in the American iron and steel industry; the first medal was awarded to Mr. Fritz in 1902 in celebration of his eightieth birthday. Members of the Institute who have received this medal include: Elihu Thomson (A'84, F'13, HM'28, member for life, and past-president); Guglielmo Marconi (HM'17); Ambrose Swasey (HM '28); Edward D. Adams (A'10); Elmer A. Sperry (M'29); John J. Carty (A'90, F'13, HM'28, member for life, and past-president); Herbert Hoover (HM'29); and M. I. Pupin (A'90, F'15, HM'28, member for life, and past-president). Other John Fritz medalists, no longer living, include: George Westinghouse (A'02); Alexander Graham Bell (A'84, M'84, and past-president); and Thomas A. Edison (A'84, M'84, HM'28).

Mr. Jackling was born at Appleton City, Mo., in 1869 and was graduated from the Missouri School of Mines in 1892. After spending a few years in teaching and in technical work in connection with mining operations he turned his attention to construction and operation of metallurgical works and embarked upon his notable career in that field as a pioneer in mass production of copper from low grade ores. The improvements in the production of copper conceived and originated by Mr. Jackling have resulted in a great increase in the world's production of copper, and a reduction in its cost. The electrical industry, as well as many other modern industries, are greatly indebted to Mr. Jackling for these improvements in the production of copper.

Mr. Jackling was director of explosives for United States government during the World War and in this capacity performed distinguished service. He is also esteemed in many sections of the western United States for his interest in the communities which under his direction have been built up at the properties of which he is the head. He is president and director of several copper mining and related companies. For his public and industrial services he has been honored by the distinguished service medal of the United States Government in 1919, the gold medal of the Mining and Metallurgical Society of America in 1926, and the William Lawrence Saunders gold medal of the American Institute of Mining and Metallurgical Engineers in 1930.

Noted Engineer Honored on Retirement

Robert Ridgway, chief engineer of the board of transportation of the City of New York, N. Y., retired on November 1, 1932, after having worked for the city for 48 years. On the date of his retirement he was the guest of honor at a dinner given at the Engineers' Club by 105 leading engineers of the country. A feature of this event was Mr. Ridgway's tribute to those who had worked with him during this period.

Mr. Ridgway was born in Brooklyn, N. Y., in 1862. Although he secured his education in the public schools of Brooklyn and at home, he has received honorary degrees of M.S. in C.E. from New York University in 1915, A.M. from Harvard University in 1925, and doctor of engineering from Lehigh University in 1929. After spending 2 years with the Northern Pacific Railway as chainman, rodman, and leveler in Montana and Wisconsin, he entered the employ of the aqueduct commission of New York City in 1884 and remained with the city from that time until his retirement. During this period he has supervised the construction of many of the city's subways and elevated lines and built many of the tunnels and aqueducts which have been of such tremendous importance to the development of this city. He has also been a member of the Chicago Traction and Subway Commission, chairman of the board of engineers for the Transbay Bridge, San Francisco, Calif., member of the Colorado River Board of the United States government, Hoover Dam Project, consulting engineer for the Japanese Government Railways and to the cities of Tokio and Osaka, and consulting engineer on subways for the City of Chicago. Mr. Ridgway is a member of several engineering and scientific societies and is a past-president of the American Society of Civil Engineers.

Unemployment Relief Plans Throughout Country Progressing

CONSIDERABLE experience in means for alleviating unemployment and providing relief to the more destitute members of the engineering profession was gained during the winter 1931–32 by many Sections of the Institute. This experience is proving of great assistance in the formulating of plans for relief to engineers during the coming winter, and should make the 1932–33 efforts even more effective than those of last winter. A summary of the activities of some of the Institute's Sections during the past winter was given in ELECTRICAL ENGINEERING for November 1932, p. 809–13.

For the coming winter, most of these sections report that the activities planned are similar in scope to those of last year, although changes are being made in the methods of securing work and of providing financial assistance. Sections generally have found that the conducting of surveys of industrial organizations in their community, for the purpose of determining positions which might be filled by men on the unemployed list, have produced meager results. However, where an energetic campaign has been conducted to create new positions in industry and to "sell" business organizations of all sorts, including the wholesale and retail distributing units, even department stores, on the idea of using engineers in positions for which it was not previously realized that they were valuable, the results have been surprisingly successful. The possibilities of extending this type of work are realized by many of the Sections, and others doubtless would do well to give consideration to its possibilities.

In most localities the Institute Sections are cooperating with the local Sections of the other engineering societies in assisting the local civic organizations that are providing relief to the entire community. One of the most important lessons that was learned last year in the localities where this type of relief was attempted is that the engineers must, themselves, remain active on the civic relief groups, in order to insure that the members of their own profession secure their proper proportion of relief. This has been found to apply not only to providing employment, but also to the provision of financial assistance to those for whom no employment is found. The importance of this phase of the work needs to be emphasized in many communities. The local civic bodies carrying on the general relief work are almost universally capable and anxious to be impartial. However, activities of other groups require that out of loyalty to their profession, Sections of the Institute should secure representation on these civic bodies, and should add their voices to secure a fair distribution of relief to all industrial groups.

In the campaign for funds to be used this winter, an effort is being made in several communities to increase the number of contributors to these funds, rather than to increase the amount of individual contributions. The fairness of this plan needs no comment here. Willingness is being shown also by those still employed to cooperate in the plans for spreading work among the largest number possible and thus reduce cases of extreme hardship. The larger cities, of course, are the most active in providing unemployment relief because it is in those communities that the greatest need occurs. It is in the larger cities, however, that the greatest difficulty is encountered in making contact with needy cases. In the smaller communities, especially those not having many industries, concerted action by engineers has been found almost unnecessary, partly because more intimate contact between members of these communities is possible and partly because those requiring assistance are more likely to be aided by their friends and acquaintances.

Letters have been received from many Sections of the Institute, outlining the plans for the coming winter. Some of these are summarized or printed in full in the following paragraphs in the hope that a circulation of these ideas may be of assistance to other Institute Sections.

NEW YORK CITY

In the metropolitan area of New York, N. Y., the local Section of the Institute is acting through the Professional Engineers Committee on Unemployment, the activities of which last year were presented in some detail in ELECTRICAL ENGINEERING for November 1932, p. 809–11. Activities for 1932–33 were started by the chairmen of the New York Sections of 4 national engineering societies getting together and deciding upon the work to be done. An organization was formed with Rear Admiral Frederic R. Harris, retired, as general chairman. H. deB. Parsons, who was general chairman last year, is serving this year as chairman of the advisory committee. As last year, United Engineering Trustees, Inc., is acting as treasurer. The working committees for the coming year are as follows: *finance committee*, T. F. Barton (A'12, F'30), chairman; *relief committee*, Ole Singstad, chairman; *publicity committee*, E. E. Dorting (A'13, M'22), chairman; and *clearance committee*, Alfred D. Flinn, chairman.

One change from last year is in providing for contributions to be paid in weekly payments extending over a period of 20 weeks, in addition to the alternative of making donations in 5 monthly payments as was provided last year. Following are excerpts from a statement made by the chairman of the New York Section of the Institute.

"The incoming committee is impressed with the organization developed last year, and realizes fully the successful outcome of their efforts in providing relief to engineers in the [N. Y.] metropolitan territory during 1931–1932. The plans for this year's operations will not depart from those of last year, and with the early start made we expect to accomplish as much as last year, and hope to do even more, since we are convinced that the demand this year will exceed that of last year. The united effort of local sections of 4 engineering societies in this work results in a unity of purpose and in efficiency and economy in handling the work. We feel that we are able to accomplish our objectives by providing:

"1. A suitable place for the registration of unemployed engineers, both members and non-members of the societies.

"2. An organization for the soliciting of funds to be used entirely for relief purposes.

"3. Establishing contacts with other relief committees in the community and in this way obtain temporary employment for a large number of the men registered with us."

"Our registrants are primarily interested in obtaining work, and it is gratifying that by far the larger part of our relief comes as a result of obtaining employment for these men. Last year for each dollar expended by the Professional Engineers' Committee on Unemployment in direct relief, a total of approximately $6 was paid to our registrants for work created by other relief organizations in the community and paid for by them. (**Editor's Note:** Efforts of the P.E.C.U. in securing for engineers a proper proportion of the relief afforded by the Emergency Unemployment Relief Committee of New York City has been an important phase of the work and is one that can be duplicated easily in any community.) This year we are assured of the hearty cooperation of other relief agencies, and if possible this year we should like to increase the 6:1 ratio to an even higher figure.

"Contributions from our members and friends to date are in line with last year, and we are confident that our membership with the full realization of the problem at hand will respond liberally so that the total amounts collected for the year will be gratifying, not only to the committee but to the membership at large."

PLANS OF SOME OTHER CITIES

Excerpts of letters received from some other of the sections follow. In presenting this information an effort has been made to include suggestions for the coming year. It is felt that records of last year's accomplishments, however important, were covered to a considerable extent by the article in ELECTRICAL ENGINEERING for November 1932, p. 809–13, previously referred to.

The relief program in Boston, Mass., undertaken by the Emergency Planning and Research Bureau, Inc., was reported in some detail in ELECTRICAL ENGINEERING for November 1932, p. 811–12. The following statement of the Honorable Joseph B. Ely, Governor of Massachusetts, indicates the value of this work: "Several of the state boards lack the necessary funds for obtaining information which is very desirable for the conduct of their work. The Emergency Planning and Research Bureau has taken over this work, and has already furnished the state agencies valuable data which would not otherwise have been available." Of interest also is the following statement of Philip Cabot, head of the department of public utilities, graduate school of business administration, Harvard University: "You (the members of the engineering and architectural societies of Boston) have recognized better than others that the cost of planning is far less than the expense of correcting errors and of living with mistakes; that the losses imposed by uncoordinated, sporadic,

and parochial development will not long be tolerated, and that when the time comes for broad planning, facts must be available on which it can be based. You have grasped the fact that slack times should be used for compiling and interpreting facts which will be needed in busier periods. You have properly confined your work to the collection of those facts which will be essential to those organizations which in the future must plan the development of this crowded district."

From the Philadelphia Section: "Our experience indicates a campaign for raising funds by the affiliated societies for the purpose of relief should be carefully approved and an organization established thoroughly in accord with the project before launching into the campaign. One of the chief difficulties is personally contacting the membership. Taking Philadelphia for illustration, the members reside throughout Philadelphia and the suburbs, part of Pennsylvania, New Jersey, and Delaware. Subscription cards were prepared with the name and address of members and for the A.I.E.E. were arranged by firms and by geographical location, so as to facilitate the work of soliciting on the part of those members on the fund raising committee. It was not possible personally to contact the membership outside of Philadelphia and the immediate suburbs. In these cases, an appeal was made by letter. The most effective way to raise funds is through official endorsement and solicitation being carried on among the technical employees by the firm; next is by personal contact, the smallest contributions being received in amount as well as in number by letter."

Also, the following is taken from an article describing the work of the Philadelphia Technical Service Committee (see ELECTRICAL ENGINEERING for November 1932, p. 813 and July 1932, p. 526): "Too little emphasis ordinarily is placed upon the necessity for providing useful work for these unemployed to perform along the general lines of their experience and capabilities. After a man has been out of work for an extended period and has tramped the streets in a useless endeavor to find a job, he begins to lose confidence in himself and in his profession, and he needs the kind of job which requires him to use his brain and to employ the experience which he has acquired in previous positions."

Funds raised by the Pittsburgh Section, totaling $646.25 for the months of June to October, inclusive, 1932, are turned over to the Engineers' Relief Committee of Pittsburgh which, as of the first of November 1932, had raised approximately $11,000. Distribution of these funds, as of May 28, 1932, was reported in ELECTRICAL ENGINEERING for November 1932, p. 813, and is divided between loans and contributions to individuals. It is stated that "it is planned to continue the work during the winter in much the same way as it has been handled in the past. The relief work has done a great deal of good, although it is on a small scale, since it has helped men who would probably not have received help through the ordinary relief channels."

From the Dallas Section: "The Dallas Section has no formal program of unemployment relief activities to be undertaken during the coming winter. It is not thought that a formal program here can be justified, because of the relatively small number of unemployed engineers and of the comparatively few opportunities in this Section's territory for additional technical employment. The members of Dallas Section as individuals cooperate with the local civic relief organizations, which have under way now a drive for funds."

From the Spokane Section: "Our program for unemployment relief for the coming winter will be the same as that practised last year. This consisted of cooperating with the local group of Associated Engineers. This organization is comprised of engineers of all branches and holds weekly noon-day meetings. Their unemployment committee is composed of a representative from each of 4 local sections of national societies. This committee has functioned satisfactorily in the past. It has been instrumental in locating jobs for numerous men. Its members have contacted many employers to whom they have told the story of why engineers should be employed in almost any line of work because their training as engineers has fitted them for work over a broad range. At present there are practically no unemployed electrical engineers who are members of this section. They have found work in various other lines, especially commercial."

Independent Action Taken by San Francisco Section

From the San Francisco Section: "Our activity in San Francisco has been purely within our own Section. The other societies in San Francisco have so far as I know taken care of their own members. This plan has worked very well here. It is in keeping with the suggestions of President Hoover as regards national relief and that is that each community take care of its own needy. It has proved very efficient and without waste. The collection of the relief fund is based upon an administrative period of 6 months. Actual experience in the operation of the fund during the first 6 months showed a surplus and it was decided to carry this surplus over into the fall and winter period rather than return it to the original donors, this on the theory that the unemployment situation would become more acute at that time. Accordingly, the fund was divided into 2 parts, a small amount being held for current necessities and the balance placed in a savings account. No attempt was made to collect delinquent pledges, and voluntary contributions were discouraged. We, therefore, find ourselves in a position to enter the fall and winter period with a reserve fund on hand, and anticipate no difficulty in meeting possible drains upon the fund through a revival of the pledges and voluntary subscriptions. We are particularly fortunate in San Francisco in the rather close affiliation among the members of the 4 principal engineering societies; for instance, through the interlocking directorship of the San Francisco Branch of the Engineering Societies Employment Service. Unless the situation proves exceedingly difficult, we look forward to carrying on through the winter season with a fair degree of success through the operation of the relief fund. The funds are in the hands of a trustee and are administered separately from the funds of the San Francisco Section of the A.I.E.E."

From the Atlanta Section: "The Atlanta Section was instrumental in having an executive committee consisting of the chairmen of the electrical, mechanical, and civil engineers and architects to consider this (unemployment) problem. This executive committee has been in operation approximately 9 months, and has been instrumental in assisting engineers to find employment within our district. If an engineer needs assistance the matter is brought to the attention of this committee and a very definite effort is made by us to find part time employment or some other means of assistance. The situation in regard to engineers in Atlanta and Georgia has not been as severe as in other states. Most of the firms in this vicinity have cooperated on the basis of sharing the engineering work. For instance, a company employing quite a number of engineers have reduced their work to a half-time basis so that as many engineers as possible could be given a livelihood. Also, a number of engineers that were released have found employment in other lines within the state. I do not mean to imply that we are in a position to absorb additional engineers in this district, but do feel that we have been instrumental in assisting engineers in keeping in employment. We have not given very much publicity to this activity rather depending upon the members of the Societies mentioned above to bring to our attention worthy cases. So far we have confined our assistance to members of the societies mentioned above, but in case of a worthy cause we would also assist an engineer not affiliated with one of these societies."

4 Per Cent Loans Made by Portland Section

The Portland Section, as outlined in ELECTRICAL ENGINEERING for November 1932, p. 813, is working with the Oregon Technical Council in making loans to engineers at 4 per cent interest. Further information from this Section follows: "At present we are soliciting subscriptions for funds to be used for loans this winter as our balance is getting low and only one note has been repaid. Last year we had relatively few large subscriptions, but this year we are trying to get a large number of small subscriptions. The local section of each founder society solicits the funds and pays all expense of the solicitation, while the administration and expense of handling this fund is paid by the Oregon Technical Council. In conjunction with this loan fund, we have an employment committee which has been successful in placing many engineers in such places as timekeeper, foremen on construction jobs, watchmen, and many other jobs."

From the Milwaukee Section: "All of the work of the Milwaukee Section of the A.I.E.E. has been in connection with the work done by the Engineers Society of Milwaukee, with which we are affiliated. The Engineers Society has appointed a special investigator to collect information on the unemployment of engineers, through questionnaires among the members and through personal solicitation regarding the possibilities of work among employers. The re-

sult of this work has been to show that approximately 150 engineers are without employment at the present time. A recent secondary questionnaire determined that, among these 150, only 2 are in serious distress. These men are being helped by monthly appropriations from the funds of the Engineers Society. There seems to be little prospect of increasing the employment in the near future from industrial sources. However, a considerable amount of municipal and government work is under contemplation, and it is expected that some placements will be possible in this manner. It appears that the depression has in many cases required engineers of a high grade and of good professional standing to take up work in other lines—in many cases with marked success. This may mean a permanent displacement of men of this type into other lines of work."

From the Utah Section: "The membership of this Section numbers about 53. At present it does not seem advisable for it to take up independent relief work. Engineers in this section of the country are individually joining in the general relief movement carried on through cooperation of societies, clubs, and local groups."

Fewer Unemployed Engineers Listed in Colorado

From the Denver Section: "The Denver Section, as the other Colorado sections of 4 national engineering societies, has combined its efforts toward relief of unemployed engineers with the Colorado Engineering Council, in the same manner as done last year. Pledges to the Citizens' Unemployment Committee are marked 'For relief of engineers' and funds so derived are made available to the Colorado Engineering Council's relief committee. Approximately 190 engineers and draftsmen are listed with the committee at present. This is less than at the same time last year, although in the late winter the number reached 247 last year, with an increase anticipated this year. Approximately $10,000 was distributed in this way last year. We hope that the funds made available in this campaign will be greater. The men have been employed on engineering work which, if resulting in construction, will produce employment for a large number of men, such as flood control, city drives, and parks. Direction of this work has been done by prominent engineers who have donated their services. Men are paid $3 a day employed, and the work is rotated to distribute the benefits as far as possible."

From the Oklahoma City Section: "We have read of the activities of various Sections in unemployment relief work in the March and November 1932 issues of the Electrical Engineering and are deeply impressed by the efforts described and would be glad indeed to contribute to the general fund of information had we any experience with the problem. As a matter of fact, the situation in this Section seems not at all comparable to that in the more populous centers. Due, no doubt, to the fact that practically all of our members are in the employ of utility organizations which have followed the policy of apportioning the available work on a reduced time basis, thus avoiding the distress occasioned by dropping men from payrolls. There is not a very large membership in the other engineering societies in this locality and thus far, conditions do not seem to warrant the establishment of any particular program of relief work. This is the consensus of opinion of our executive committee. We believe that, in general, our membership is favorable to still further reductions in individual incomes if necessary to avoid total unemployment. There is, of course, a limit to the extent to which this practise may be carried and it is entirely possible that we may eventually find it necessary to give some special consideration to relief work."

State Funds Used in Chicago

From the Chicago Section: "The Chicago Section in cooperation with the other engineering societies is actively working on the following program. State funds have been provided for unemployment relief, part of which are devoted to direct relief such as supplying food and other essentials, and another part to the payment for actual work performed for municipalities and other public bodies. Work of the latter nature has so far been principally confined to common labor, but the engineering societies are now working on 2 specific phases of a program which it is expected will make it possible to care for many, if not all, of the engineers in need of relief during the coming winter. The first phase of the above project consists in finding types of work suitable for engineers, such as making traffic studies, bringing engineering records of the city and other public bodies up to date, all of which cannot be done with the present employed forces. The second phase consists of finding the engineers who are in need of help, making the necessary classification, and seeing that they obtain work of a suitable nature, as outlined above. In addition to the above, certain of the local sections of the engineering societies are making direct loans to needy members, although the extent of this work and the amount of money distributed is relatively small."

Electragists Revert to Original Name.—At the annual meeting of the Association of Electragists, International, held in Kansas City, Mo., October 10–12, 1932, it was decided by unanimous vote to change the name of this association to the National Electrical Contractors' Association. This latter name is the one under which it was organized 31 years ago. The trademark "Electragist" will still be used in conjunction with the association name as identification of membership.

Report on Banking Issued.—After an exhaustive study of the banking situation by its staff experts, the National Industrial Conference Board, Inc., has issued a report under the title "The Banking Situation in the United States." One of the conclusions reached by this study is that the various measures recently enacted by Congress for the relief of the financial situation in the United States are for the most part temporary expedients; and that while some of them may contribute in a certain degree to the permanent improvement of banking conditions, it would be an illusion to conclude that they are capable of providing a lasting solution of the American banking problem. Many aspects of the banking situation are discussed, and the significance of the startling developments in the field of banking that have taken place during the last 2 years are set forth lucidly in this report.

World's Fair Electrical Group Dedicated

The electrical group of Chicago's 1933 World's Fair—A Century of Progress Exposition—comprising the radio hall, communications hall, and the electrical building was dedicated on Wednesday, October 12, 1932, under the auspices of the Electric Association of Chicago. B. E. Sunny (A'03, F'13) former president and chairman of the Illinois Bell Telephone Company, and director and member of the executive committee of the General Electric Company delivered the address of dedication. Mr. Sunny is a trustee of the 1933 Exposition and was a director of the World's Columbian Exposition of 1893. W. O. Batchelder (A'08), president of the Electric Association of Chicago, presided at the ceremonies. Rufus C. Dawes, president of a Century of Progress Exposition, spoke on behalf of the fair.

The electrical group is a huge sickle-shaped structure nearly $^1/_4$ mile long which rises on Northerly Island and faces a beautiful lagoon opening into Lake Michigan. A bridge connects it with the Hall of Science which is located opposite on the mainland. The story of the development of electricity for mankind's uses which has occurred in the century which the exposition will celebrate will be unfolded by means of moving, animated exhibits in this group of buildings. Manufacturers of electrical machinery, equipment and supplies, producers of electrical devices of all descriptions, radio manufacturers, and companies providing the nation with telegraph and telephone service have already contracted for extensive blocks of space in the electrical group and are developing their exhibit plans.

Sale of Electrical Goods in Southwest Analyzed.—The answer to the question of who gets the consumer's dollar spent for electrical equipment and supplies in the Gulf Southwest hardware trade is one of the interesting sidelights brought out in the Department of Commerce's newest regional commercial study "Hardware Distribution in the Gulf Southwest." This publication offers to interested manufacturers and distributors a thorough study of the wholesale and retail structure of the trade in this territory. Among the findings brought out are that approximately 28 cents of each dollar spent for electric wiring supplies by customers of the hardware trade is retained by the retailer, 14 cents goes to the wholesaler, and the remaining 58 cents goes to the manufacturer. In small electrical appli-

ances it is revealed that the split-up is 32 cents to the retailer, 12 cents to the wholesaler, and 56 cents to the manufacturer. Other products show different distributions. The average gross profit margin of electrical wiring supplies was found to be 19 per cent; small electrical appliances, 18 per cent; mechanical refrigerators, 33 per cent; radios, 22 per cent; and vacuum cleaners, 21 per cent. Copies of the report may be obtained at 40 cents each from the Superintendent of Documents, Government Printing Office, Washington, D. C., or from district offices of the Bureau of Foreign and Domestic Commerce in principal cities of the country.

Volume Issued on Geophysical Prospecting

"Geophysical prospecting methods are, in final analysis, simply means of geological surveying. Almost every variation in physical properties of rocks, minerals, and ground waters gives rise to anomalies which under favorable conditions might be measured and used to trace formations, contacts, and structures...." This statement is contained in the foreward of "Geophysical Prospecting, 1932," a new volume on a new science, published by the American Institute of Mining & Metallurgical Engineers. The cloth bound volume can be secured from this organization at 29 West 39th Street, New York, N. Y., at a cost of $5 postpaid in the United States.

The contents of this work include: 2 papers evaluating the geological utility of various geophysical methods; 4 papers containing descriptions of the application of electrical geophysical technique to the study of geological problems of a type to interest civil engineers; 2 papers describing the use of magnetic methods for investigating subsurface conditions; a discussion of the effect of moisture in rocks and soils on their electrical conductivities; a description of the construction and uses of geophones; and numerous other papers dealing with special phases of electrical, magnetic, seismic, and gravitational methods in geophysical exploration.

Power Use on Farms Increasing.—An analysis of the use of power machinery on the farm is presented in a recent issue of the bulletin of the National Industrial Conference Board, Inc., New York, N. Y., which states that the hand methods formerly in use required about 60 hr of labor for one man to harvest and thresh an acre of wheat, whereas with the self-binder and stationary threshing machine, the time was cut to from 4.5 to 8 manhours, and with the coming of the "combine," the manhours were reduced to from $^1/_2$ hr to $1^1/_2$ hr. The gain in efficiency per worker achieved by these mechanical aids is from 4,000 to 12,000 per cent, with a consequent labor displacement of 97.5 to 99.2 per cent. These figures are based upon the records of the principal wheat growing states of this country, the greatest gain in efficiency being noted in California. The continuance of this trend is pointed out in the bulletin, indicating the possible elimination at some future time of wheat farming where such machinery is not used. Although tractive power represents the chief use of mechanical power in farming operations, there has been a considerable use of electricity in farming where central power stations are accessible.

Accidents Reduced by Highway Lighting.—During the past 18 months, 2 main highways in Schenectady County, New York State, have been illuminated at night by highway luminaires. During this period the 2 highways have had 42.3 per cent fewer night accidents than during the preceding 18 months, and 21.2 per cent fewer day accidents. The emphatic reduction in night accidents, which is double the improvement in day accidents, doubtless is due to the installation of highway lighting, as other road conditions have remained unchanged.

Hoover Dam Cableways Ordered

In connection with the construction work at Hoover Dam, the Six Companies, Inc., recently awarded contracts for 5 20-ton cableways. These cableways will be used to raise excavated material from the canyon, place concrete in the dam, and handle equipment and materials. Two cableways with moving towers running on tracks benched on both the Nevada and Arizona sides, with spans of 2,580 ft each, will serve the spillway area. The dam site will be covered by 2 cableways of similar type, but with spans of 1,380 ft each. The fifth cableway will be of the radial type, with a 1,365 ft span, and will cover the lower portals of the spillway and penstock tunnels.

Six contracts have been awarded for the various parts of this equipment. The motors and control equipments are now being shipped from the East Pittsburgh works of the Westinghouse Electric and Manufacturing Company and include 5 500-hp 585-rpm main hoist and trolley motors for the 5 20-ton cableways, 9 motors ranging in size from 75 to 150 hp for moving the cable towers sideways, and 33 control boards. All motors are of the wound rotor type, operating from 2,300-volt 3-phase 60-cycle power, and equipped with full magnetic reversing plugging control.

Manual on Endurance of Metals Available.—In 1927 the Engineering Foundation published a "Manual of the Endurance of Metals under Repeated Stress" in which the views and data upon the fatigue of metals were summarized for designers, inspectors, and testing engineers. The Engineering Societies Library, 29 West 39th Street, New York, N. Y., has acquired the remaining stock of this work and will be glad to send a copy to any one interested, upon receipt of 25 cents to cover shipping costs.

Montefiore Award for 1932 Announced

The George Montefiore Prize, which is awarded triennially for articles published during the 3 years preceding the award, has been determined for this year by the jury which met at Liege, Belgium, October 1 and 2, 1932. The prize, which this year amounted to 21,500 fr., has been divided. Three articles were chosen: these are by L. Barbillion, engineer, professor at the University of Grenoble; A. Guilbert, Doctor of Sciences, engineer in Paris, and C. J. van Griethuysen, engineer at Marcinelle. Electrical Engineering for February 1932, p. 135 carried an announcement of this award, inviting the submission of articles to the jury.

The award is for the best original works contributing to the scientific or technical advancement of electricity. The authors may be from any country. The prize is administered through the Association des Ingenieurs Electriciens, or a national electrical society of Belgium. This association is an outgrowth of the Institut Electrotechnique Montefiore, which is attached to the University of Liege.

The jury, under the direction of Omer De Bast, director of the Institut Electrotechnique Montefiore, is composed of 10 electrical engineers who are well known in the electrical industry in Belgium and other countries, and includes as a member A. E. Blondell (A'05, HM'12), professor at the École National des Ponts et Chaussees of Paris. The next meeting will be held in 1935 at which a prize of 22,000 fr. will be given.

Chromium Plating Patent of Doctor Fink Upheld.—Validity of the patent of Dr. C. G. Fink, professor of electrochemistry at Columbia University, New York, N. Y., covering commercial chromium plating, was sustained by an unanimous decision of the U.S. Circuit Court of Appeals for the second circuit, in which all claims of the inventor to his basic methods for chromium plating were upheld. The suit was brought by United Chromium, Inc., holder of Doctor Fink's patent, against the International Silver Company, which based its defense upon the research performed by the U.S. Bureau of Standards, the Eastman Kodak Company, and the Westinghouse Electric Manufacturing Company. The Court of Appeals held that this work failed to anticipate the work of Doctor Fink, and that the patent provided the method with which "for the first time the art could turn out chromium plating with certainty." The work of Doctor Fink was revealed as one of the great achievements of modern chemical research. For many years chemists attempted to solve the problem of plating metals with chromium, but without success. Doctor Fink worked at the problem, and after making numerous experiments he finally evolved a basic method to plate objects with a uniform and adherent coating of chromium. He found that the chromium particles could be deposited successfully in a durable coating only in the presence of a catalytic agent in the plating

bath. Proper concentration of this catalyst in the plating bath eliminates erratic and uncertain results in chromium plating.

Electrical Engineers Increase in Number

A comparison of 1920 and 1930 census figures gives a vivid picture of changes that have been taking place in occupational distribution. This data which can be obtained from the Superintendent of Documents, Washington, D. C., for all occupations and sections of the country, has been summarized in a recent bulletin of the Personnel Research Federation, 29 West 39th St., New York, N. Y. The following paragraph is taken from this bulletin:

"It seems that many more men have been entering professional careers. Only in the profession of veterinary surgery was there a substantial decline. The supply of male dentists increased a trifle faster than the total working population, and of physicians and surgeons a little more slowly; but the number of women in these professions definitely decreased. Most spectacular of all, there were more than twice as many electrical engineers in 1930 as in 1920. Stock brokers and insurance agents also more than doubled in number. The transfer of functions from home to shop is reflected in the data regarding men and women workers in cleaning, dyeing, and pressing establishments. The 1930 figures are 389 per cent and 473 per cent, respectively, of those from 1920."

The data given in Table I summarized the changes in the engineering profession over this 10-year period. In addition to the males shown in this table, there were in all occupations in the United States 10,752,116 females, 127 per cent of the number employed in 1920.

Table I—Comparison of 1920 and 1930 Census Figures for Engineers

	U. S. A.—Male		N. Y. C.—Male	
	1930	% of 1920	1930	% of 1920
All occupations	38,077,804	115	2,324,599	126
Civil engineers and surveyors	102,057	158	6,782	141
Designers, draftsmen, and inventors	93,518	149		
Electrical engineers	57,775	214	5,475	223
Mechanical engineers	54,338	141	4,120	121

Letters to the Editor

CONTRIBUTIONS to these columns are invited from Institute members and subscribers. They should be concise and may deal with technical papers, articles published in previous issues, or other subjects of some general interest and professional importance. ELECTRICAL ENGINEERING will endeavor to publish as many letters as possible, but of necessity reserves the right to publish them in whole or in part, or to reject them entirely. STATEMENTS in these letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the American Institute of Electrical Engineers.

Rudolph Frederick Schuchardt —An Appreciation

To the Editor:

On October 25, 1932, there passed from among us one of God's noblemen, Rudolph Frederick Schuchardt, a past-president of the American Institute of Electrical Engineers, and chief electrical engineer of the Commonwealth Edison Company.

Modest, courteous, lovable, a clear thinker, an able organizer and executive, Mr. Schuchardt, in spite of his multitudinous duties and responsibilities was never too busy to help a friend or serve his fellow man.

For the past 10 years, his life was permeated with ill health and saddened by the tragic loss of his beloved wife, but he refused to be crushed by fate and during this period, faithful to his high ideals, rendered conspicuous service. Engraved upon his heart was the gallant motto, "Ich dien."

Honored by his friendship for a quarter of a century, I wish to add my tribute to the memory of so fine a gentleman, so lovable a friend.

Very truly yours,
H. L. WALLAU (A'00, F'13)
(Chief Electrical Engineer, Cleveland Electric Illuminating Co., Cleveland, O.)

Brass Tacks in Economics

To the Editor:

The article under the title "Brass Tacks in Economics" by David Cushman Coyle in ELECTRICAL ENGINEERING for October 1932, p. 712–3, is one of the most suggestive yet printed in the symposium "Has Man Benefited by Engineering Progress?" In a few words it points out the principal problems still to be solved by our Western civilization.

Unless some such solution is seriously undertaken during this generation or the next, it is most probable that some form of socialism or communism will be adopted by most Western nations or by a league of all the nations which are predominantly Caucasian.

If the present Russian experiment proves successful within the next few decades, then a league of this kind will probably be formed at a much earlier date. Once the masses of the Western nations realize that the masses of Russia have reached a standard of living equal to or approaching theirs, without the savage competitive system of the capitalistic world, it would be easy for the leaders of the movement to obtain sufficient following for the establishment of a similar system, either by peaceful and legal methods or by revolution. If the 200,000,000 Russians are living happily without unemployment or idleness, with ample time for recreation and with all the luxuries which we Westerners consider necessities, if they have no arrogant multi-millionaires, no powerful captains of industry, no ruthless commercial warfare, no crowding of the weak by the strong, it will not be difficult for the Western people to realize that there is a new theory of political economy which may be nearer the ideal state than that under which they live.

It seems to me, however, that to carry out Mr. Coyle's suggestion it would be necessary to overcome 3 almost insurmountable obstacles. The first of these is the usual inefficiency and the frequent corruption of most government channels. If heavy taxes on large incomes are collected and the proceeds spent in public and semi-public construction, the collection and the expenditures must be in the hands of a political bureaucracy. Can we depend on the incorruptibility of the members of this bureaucracy and on the ability with which their work will be performed? In view of the corruption and inefficiency so frequently found in our national, state, and municipal administrations, is it possible for any thoughtful man to believe that with our present methods of electing our representatives, our officials, and our judges, these taxes will be collected fairly and economically and spent efficiently and honestly? The first step, then, must be the improvement of the morals of our officials, and as their morality is but a reflection of the morality of the citizens, we must begin by improving the morality of the citizenship. This lack of morality is probably due to the complete breakdown of our religious systems which are the foundations of our morality. If all that the citizens do toward living a better life is to give lip service to their religious leaders on Sunday and act so as to keep just within the law on other days, then little can be expected of real human progress. It would seem, therefore, that the first step required to insure the success of the proposed plan would be to develop a high sense of moral integrity in the citizenry and that little can be gained until that is done.

The second problem which seems difficult to solve is how to give a suitable incentive to inventors and promoters, and how to obtain the advantages of quantity production, of large research and development laboratories. If we had had no large accumulations of capital or rather if the inventors, promoters, and financiers had not seen the possibilities of obtaining great wealth and power, we probably would not have been able to obtain many of the benefits of the present machine age. These inventions may not have served to develop greatly the spiritual aspirations of the human soul but the railroad, the telegraph, and telephone, the dynamo and the internal combustion engine, the aeroplane,

the cinema and the radio, have done much to change our world and this scientific and mechanical progress has undoubtedly had considerable effect in the elevation of the human spirit. But many of these things would not have been possible without capital and without the spur of the possible wealth, glory, and power to be attained if successful. Similarly, untold wealth has been lost in trying to develop inventions which have proved unsuccessful, and for that reason it would seem that substantial rewards should be permissible for the adventurers in the fields of science and invention.

The third problem is the necessity of having a union or league of all Caucasian nations before any such system can be put in effect, because no plan of this nature could be successful unless it could be carried out simultaneously in the other nations with which we have to live in this small planet, or at least in a substantial part of the nations which are generally included in our European civilization. As a matter of fact, all the peoples of the world should form part of this federation, but probably the experiment could be properly tried with fair chance of success if, at first, all the basically Caucasian nations would join in it, leaving to the others the opportunity of joining it later. Without practically universal acceptance, the interference from the outside, where institutions of the purely capitalistic, competitive type still ruled, would make the plan unworkable.

Very truly yours,
Gustavo Lobo (A'01, F'12)
(President and Treasurer,
Kelvin Engg. Co., Inc.,
New York, N. Y.)

Too Much Investment Money!

To the Editor:

In the October 1932 issue of Electrical Engineering, p. 712–3, David Cushman Coyle makes the direct statement that there is too much investment money. His whole article, "Brass Tacks in Economics" seems to be based on that statement, and yet he makes no attempt to support it with evidence. We have repeatedly heard the same claim before, but no attempt is ever made to prove it. This is particularly surprising to any one who has had experience in trying to sell equipment. Everywhere we meet the same statement from purchasers, that capital is not available.

If there were too much investment money we should expect that it would appear as a demand for investment securities such as high grade bonds. An excess of investment money must result in a low rate of interest on investment securities, and if the rates are compared for a period of years, we find 6 times this century when these rates dropped decidedly. These years were 1905, 1909, 1916, 1922, 1927, and 1930. If this excess of investment money caused poor business, we should expect that each of these times depression would have followed. Instead every time at least a year of good business followed, with the exception of 1930 in which case it is easy to find reasons why it did not.

Now if we turn to the peaks of interest rates on investment money, which came in the years 1903, 1907, 1913, 1915, 1918, 1920, 1923, 1929, and 1932, we find only one case, the war year 1915, in which the business was good for the following year.

There is other evidence to show that there has never been an excess of investment money in this country, but this simple comparison of the interest rates with business conditions should be enough to demonstrate that the cause of our present troubles is not a surplus of investment money. Some people have been deceived by the low rates of interest of bank loans. These low rates are never given on investment money, but on temporary reserves, on money which may be temporarily loaned on the most liquid securities, but which the holder does not desire or does not dare to invest.

Others have been deceived by the large amounts of wasted capital into thinking that there has been too much. It is not difficult to find cases of poor families spending on some useless luxury the money which they needed for food. We may think that a person who would buy a radio must have an ample surplus, but we know that often that is not the case. And in investments, money has been spent in overexpansion in times when others had difficulty in securing money for needed developments. When a speculative mania is under way, people will throw away what they need, and investors are no different in this respect from the ignorant.

1929 was a year of wasted capital from every side. Gambling profits was consumed in luxuries. The public mortgaged their future for immediate consumption. And perfectly useless business expansion took place. Each caused a loss of investment money, and we are still suffering from that loss. No business revival can take place until a larger proportion of earnings are turned into investments.

Very truly yours,
A. W. Forbes (A'12)
(Forbes & Myers,
Worcester, Mass.)

Consumption, Production, Distribution

To the Editor:

The report of the American Engineering Council committee on "The Relation of Consumption, Production, Distribution" (see Electrical Engineering for June 1932, p. 373–7) fits so many of the facts that it must contain a very large element of truth. With relatively no foreign capital, funds were available for so much plant expansion from 1923 to 1929 that many engineers and economists regarded our industrial plants as generally overexpanded while during the same period enormous sums were also used to finance the purchase of our products and for speculation.

Simple theories usually require modifications, however. Further study may show that a defective mechanism for controlling the rate and use of savings was the underlying cause of the depression. According to the classical theory of diminishing returns, the excessive diversion of purchasing power to capital uses is controlled by the diminishing returns on additional increments of capital. Why has this mechanism of diminishing returns failed to prevent excessive savings? May I suggest 4 reasons.

1. It requires time to accumulate and invest savings, more time for the invested savings to be converted into new plants, and a further period of operating the new plants before income reports can reflect a diminishing return. There is evidently a lag in the operation of the mechanism of diminishing returns which may easily amount to more than a year.

2. For concerns which are showing a consistent profit the diminishing returns on capital are reflected in a rising market price for their stocks and bonds. This appreciation of the market value of the principal is a more powerful stimulus to savings than any normal interest return.

3. The rising market values of stocks, bonds, and real estate brings a demand from speculators for the use of savings, at rates which do not reflect diminishing returns.

4. An important fraction of the total savings is used to finance purchases of our products. This use includes nearly all foreign loans, the financing of installment selling, and many other extensions of credit.

These are some of the reasons why diminishing returns do not bring about a prompt and effective regulation of savings to the need for new capital. In consequence strains are built up in the economic system until a break occurs and apparently in 1929 all the above methods of investing savings ceased to attract investors within a period of a few weeks. The flow of savings into these types of investment does not, of course, prove that the same volume of savings could not have been safely absorbed had these savings been invested in more conservative low yield engineering works.

In 3 ways this train of events might have been interrupted.

1. If there had been less savings excessive investment in foreign loans, installment financing, and speculation might have been avoided.

2. If investors had deliberately passed by the greater yield of these forms of investments and used their money to finance self-liquidating projects at a smaller yield there would have been no economic strains and no collapse of our investment machinery.

3. If when the collapse came, every one, including corporations, had immediately changed his saving habits and spent, or given away to be immediately spent, the part of his income which he had been saving, we should have had only a readjustment between different industries and not a semi-paralysis of all industry.

That any of these things should happen as the result of enlightenment or exhortation is too much to expect of human nature. Some form of regulation, probably through shifting the tax load on to the uneconomic forms of investment when these threaten to become excessive, must be developed.

Very truly yours,
F. C. Breckenridge
(Washington, D. C.)

What About the Engineer?

To the Editor:

In the *Saturday Evening Post* for November 5, 1932, Frank A. Vanderlip, former president of the National City Bank, propounds the question "What about the banks?" and dissertates upon the query with comprehensive scope in his 7,000 word but terse article.

In order to avoid further governmental regulation of our banks, Mr. Vanderlip outlines necessary changes in present practise which the banking fraternity should initiate and adopt. His article culminates in the practical suggestion that the Clearing House Committee, the Federal Reserve Bank, and the New York Stock Exchange jointly prepare a questionnaire that must be answered before any new security issue may be floated in the New York market provided the houses of issue would be amenable to the plan.

At this juncture he suggests a subsequent check by engineers to certify that money obtained for construction purposes had actually been devoted properly to such construction and what commissions or bonuses, if any, were paid. This coming from such high banking authority as F. A.

Vanderlip is a tribute to the engineer for his utility in our society beyond the scope of mere technical production.

We know that we have sometimes seen on bond circulars testimony by engineering firms as to the accuracy of statements concerning plant and property. But, as Mr. Vanderlip implies, they are far too few and these often more of form than of complete fact.

If that practise is to be effective, is to be real, the bank will need to have its own engineer whose work must prove its worth over a period of years. He will need to do more than merely report that so much money has been spent for so much construction of plant. As time goes on methods change, depreciation and obsolescence enter the scene and in the case of many enterprises the more time that elapses the more difficult it becomes to keep a clear distinction between accounted capital and effective capital. While ordinary accounting practise is an accurate procedure, management judgment over a period of years in the handling of a multitude of items in transition from earnings to profit and loss surplus and thus to effective capital, may effect material changes in effective capital and hence earning power. The proper expenditure of a given sum adds that sum to accounted capital but it may add more or less than a given sum to the effective capital, particularly over a period of time. This determination is also proper work for the engineer.

It is the banker's prerogative to make the financial decision as to earning capacity behind any specific bond issue but such decision is arrived at after careful consideration and evaluation of the contributory technical facts furnished by the engineer and by the accountant.

It is to be hoped that the engineering profession will serve to take its part in such a constructive program which will at least help to minimize the bad effects of such a financial debacle as we recently experienced.

Very truly yours,

Frank C. Czarnecki (A'15)
(37 West 39th St., New York, N. Y.)

Method for Fitting a Straight Line to Plotted Points

To the Editor:

At times it is desirable to draw a straight line through a number of plotted points and to find the equation of the line which best represents the points. There are various methods employed, such as stretching a string and drawing a line by inspection, the method of averages, and the method of least squares which gives the "best" line.

The method of drawing the line by inspection, and the method of averages, while quite simple and requiring little computation, have the disadvantage of giving inconsistent results; that is, the position of the line is influenced by the judgment of the person drawing it and therefore 2 people might not arrive at the same line from a given set of data.

The method of least squares is admittedly the best method and gives consistent results, but the computations become quite laborious when there is a large number of points.

The following method removes the inconsistencies due to the personal judgment of the computer and involves less labor in computing than the method of least squares. It is believed to be satisfactory for most engineering purposes except where a degree of precision is required which justifies the use of least squares and the lengthier computations involved.

Let (x_1, y_1), (x_2, y_2), . . . (x_n, y_n) be a series of observed points through which it is desired to draw the straight line of closest fit. Let it also be assumed that the required line

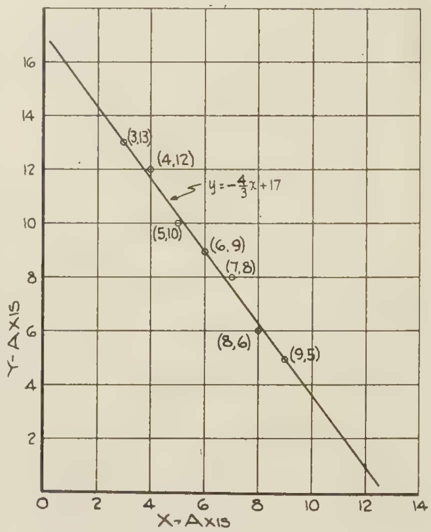

Fig. 1

will pass through a point whose ordinate is the average of all the observed values of y, and whose abscissa is the average of all the observed values of x, that is, one point on the line is (x_a, y_a) where x_a equals $\frac{\Sigma x}{n}$ and y_a equals $\frac{\Sigma y}{n}$.

If the point (x_a, y_a) is now considered as the center of coordinates, the line will have an equation of the form

$$y' = mx'$$

and the coordinates of the points (x_1, y_1), (x_2, y_2), etc., in the original data will be the deviations of the observed points from (x_a, y_a). The straight line will now pass through the new origin, (x_a, y_a), and lie in the first and third, or in the second and fourth, quadrants.

Inasmuch as the line is straight and passes through the new origin, all the points can be placed in one quadrant by giving them the same relative location in that quadrant as they had in the quadrant from which they were removed. This is the same as considering all the deviations as having the same sign. By averaging all the absolute values of the x deviations and all the values of the y deviations, the point (x_b, y_b) is obtained, where $x_b = \frac{\Sigma|d_x|}{n}$ and $y_b = \frac{\Sigma|d_y|}{n}$; $\Sigma|d_x|$ and $\Sigma|d_y|$ being the sum of the absolute values of $(x_1 - x_a)$, $(x_2 - x_a)$, etc., and $(y_1 - y_a)$, $(y_2 - y_a)$, etc., respectively.

The equation of the line passing through the origin (x_a, y_a) and the point (x_b, y_b) is

$$y' = \frac{y_b}{x_b} x'$$

$$= \frac{\frac{\Sigma|d_y|}{n}}{\frac{\Sigma|d_x|}{n}} x' = \frac{\Sigma|d_y|}{\Sigma|d_x|} x'$$

where $\frac{\Sigma|d_y|}{\Sigma|d_x|}$ is the slope.

If the line is now referred to the point (0, 0) as the origin instead of (x_a, y_a), its equation becomes

$$y - y_a = \frac{\Sigma|d_y|}{\Sigma|d_x|}(x - x_a)$$

$$y = \frac{\Sigma|d_y|}{\Sigma|d_x|} x + \frac{\Sigma y}{n} - \frac{\Sigma|d_y|}{\Sigma|d_x|} \frac{\Sigma x}{n}$$

the slope being $\frac{\Sigma|d_y|}{\Sigma|d_x|}$ and the y intercept being $\frac{\Sigma y}{n} - \frac{\Sigma|d_y|}{\Sigma|d_x|}\frac{\Sigma x}{n}$.

The sign of $\frac{\Sigma|d_y|}{\Sigma|d_x|}$ is determined by noting the signs of the deviations. If it is found that the x deviations and their corresponding y deviations have like signs the slope of the line is positive and $\frac{\Sigma|d_y|}{\Sigma|d_x|}$ is plus; if the signs are unlike the slope of the line is negative and the minus sign is used with $\frac{\Sigma|d_y|}{\Sigma|d_x|}$.

The following example, illustrated in Fig. 1, is worked out in detail to show the method.

$x - x_a$	d_x	$y - y_a$	d_y
3 − 6	−3	13 − 9	+4
4 − 6	−2	12 − 9	+3
5 − 6	−1	10 − 9	+1
6 − 6	0	9 − 9	0
7 − 6	+1	8 − 9	−1
8 − 6	+2	6 − 9	−3
9 − 6	+3	5 − 9	−4
$\Sigma x = 42$	$\Sigma\|d_x\| = 12$	$\Sigma y = 63$	$\Sigma\|d_y\| = 16$

$$x_a = \frac{42}{7} = 6 \qquad y_a = \frac{63}{7} = 9$$

The slope of the line is

$$-\frac{16}{12} = -\frac{4}{3} = -1.333$$

It is given the negative sign because the corresponding values of d_x and d_y are unlike. The y intercept is

$$9 - \left(-\frac{4}{3}\right) 6 = 9 + 8 = 17$$

and the required equation is

$$y = -\frac{4}{3}x + 17$$

The least squares line has been worked out and is

$$y = -1.35x + 17.1,$$

showing that the method described agrees quite closely with the least squares "best" line and is satisfactory for a great many applications.

Very truly yours,

Hector B. Samson (A'27)
(1729 Madison Ave., Dunmore, Pa.)

Graphical Determination of the Symmetrical Components in a 3-Phase Unbalanced System

To the Editor:

An unbalanced 3-phase system may be resolved into 3 sets of symmetrical components which are: 2 balanced 3-phase systems of opposite rotation and a uniphase component. When great accuracy is needed, these components are analytically determined with 3 equations, following a method developed by C. L. Fortescue.

As far as I know, the graphical solutions that have been suggested make use of a

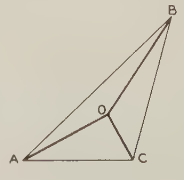

Fig. 1

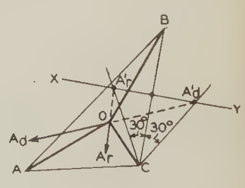

Fig. 2

different geometrical construction to determine each one of the components. In this letter, I would suggest a general solution that can be performed on a single diagram.

We shall first consider the case when there is no residual component; afterward it will be shown that the solution equally applies when the sum of the 3 vectors is not zero.

No Residual Component

Let us take the 3 unbalanced vectors OA, OB, and OC whose sum is zero (Fig. 1).

Join the points ABC of the vectors by straight lines, thus making a triangle (Fig. 1).

Through the middle point of the side BC, draw a line XY perpendicular to BC (Fig. 2). From the corner C, draw 2 straight lines, respectively, making a 30° angle on each side of BC; these 2 lines intersect the perpendicular XY at A'_r and A'_d. Joining A'_r and A'_d to the neutral O, we get the lines OA'_r and OA'_d.

OA'_r is equal in magnitude to the reverse phase component of OA; this line OA'_r should be prolonged past O to obtain the right vectorial position, which is 180° from OA'_r, to a point A_r equally distant from O as A'_r.

Similarly OA'_d is equal to the direct phase component and 180° out of phase;

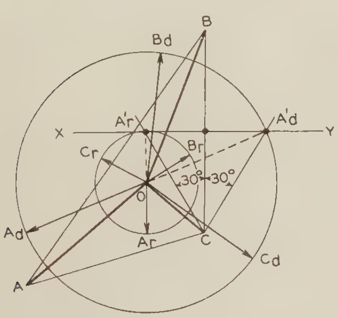

Fig. 3

prolong this vector through O by an equal length in the opposite direction.

Now that we know the components of OA in each symmetrical system, it is easy to find out the components of the other phases because they are symmetrical and 120° apart from each other. The solution is made easier if we draw 2 circles with O as center and OA'_r and OA'_d as radii (Fig. 3).

Any side of the triangle may be used to determine the initial components, the side taken always giving the components of the opposite phase: *e. g.*, side BC giving components of OA, side AB giving components of OC and side CA giving components of OB.

General Solution

The method usually followed when there is a uniphase component is to add the 3 vectors and find out their sum; the sum is equal in magnitude and direction, to 3 times the uniphase component. Afterward this component is subtracted from each vector and with these new vectors we come back to the problem as explained above.

However, it can be noted that when the uniphase component has been subtracted from each vector (Fig. 4), the new enclosing triangle $A'B'C'$ is equal to the original triangle ABC.

Also the distance between the origin of the vectors O and the center of gravity O' of the triangle ABC (Fig. 5) is equal in magnitude and direction to the uniphase component.

From the above considerations we can draw 3 conclusions:

1. When there is a residual component the enclosing triangle can still be used for the solution.

2. Joining the extremities A, B, and C of the vectors to the triangle center of gravity is equivalent to subtracting the uniphase component from each vector.

3. The triangle center of gravity, and not the neutral point, should be used for finding the symmetrical components. (When there is no uniphase component, the neutral point and the center of gravity coincide.)

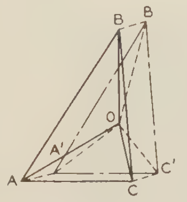

Fig. 4

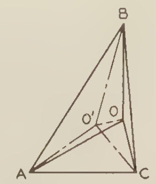

Fig. 5

Procedure

The following procedure is suggested for a general graphical solution (Fig. 6):

1. Draw a triangle around the 3 unbalanced vectors OA, OB, and OC as previously described.

2. Locate the triangle center of gravity, O' (in a triangle, the center of gravity is at the intersection of the 3 lines joining each corner to the middle of the opposite side; it is always located at $^1/_3$ of the height).

3. Erect a perpendicular XY to the side BC through its middle point.

4. From the corner B, draw 2 lines, respectively, making a 30° angle on each side of BC; these 2 lines intersect the perpendicular XY at A'_d and A'_r.

5. Draw 3 circles with O' (center of gravity) as common center and, respectively, passing through the points O, A'_d, and A'_r.

6. Prolong the lines $O'O$, $O'A'_d$, and $O'A'_r$ through O' to the opposite side of their respective circles.

We now have the 3 components for the vector OA. The direct and reverse sequence components for the other vectors OB and OC are 120° apart from the components of OA; the uniphase component is the same for the 3 vectors.

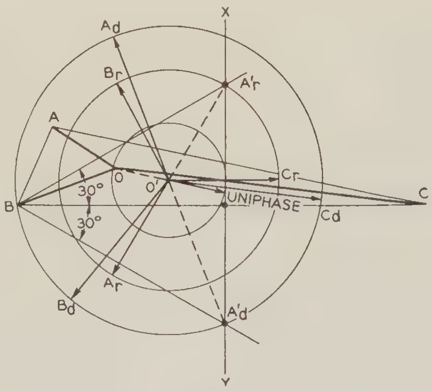

Fig. 6

Apart from its completeness, this method would be very convenient for a quick estimate of the unbalance factor.

Very truly yours,

R. Laplante (A'32)

(Shawinigan Water & Power Co., Shawinigan Falls, Quebec, Can.)

Young Engineers Must Plan for the Future

To the Editor:

The "Letter to the Editor" from Dr. Valdimir Karapetoff published in the September 1932 issue of Electrical Engineering, p. 669, proposes a fundamental change in educational methods in the United States that would be of great value to the engineering profession as a whole, were it put into practise generally. Briefly, it consists of training the engineering student along such lines that in this rapidly advancing profession he will be capable of doing modern engineering work soon after graduation, without the necessity of first going through various training and test jobs to find out what the engineering profession has been doing in the 10 years since his textbooks were written, and what it is going to do in the next 10 years. The chief advantage of such an educational method lies in the hope that an engineer trained in college to look beyond present achievements may perchance carry the habit with him into professional life.

Two years ago I listened to Dr. Karapetoff talk to a small group of prominent physicists and 2 engineers about the need for applied scientists and theoretical engineers to act as intermediaries between mathematical physicists and practising engineers. As a very pertinent example of a problem badly in need of such treatment, Dr. Karapetoff mentioned very briefly the polymerization of insulating materials in high voltage cables. In the discussion that followed, the subject of Dr. Karapetoff's talk and the purpose of his visit were completely forgotten in the advancing of hair-trigger theories about polymerization; the 2 engineers were visitors and so listened and went away without learning how to better effect an interchange of knowledge and experience with their physicist acquaintances.

It is rather apparent that any constructive action in this direction must start from the engineers' side of the fence; later perhaps, the theoretical physicists may change their attitude sufficiently to welcome with more open arms the advances of men who are motivated solely by a sincere wish to further scientific knowledge and technical achievement. For the present it seems that with a few notable exceptions, physicists do not care to extend their activities toward engineering fields, and indeed do not care to offer instruction to those who seriously contemplate applied physics and theoretical engineering.

In the research laboratories of our large electrical industries there may be found the applied scientists and theoretical engineers necessary to the rapid advance of industrial art. The small organizations are indeed fortunate to have at their call the services of such individuals. The training facilities of these research laboratories are much too restricted to supply the needs of the engineering profession in the future for scientifically trained men, and it remains for the colleges and universities to take over a large part of the burden.

The 4-year college course has in the past been the greatest stumbling block to engineering training. To get something more than a trade school education in 4 years of college and not at the same time neglect the technical courses, is at present well-nigh impossible. Formerly a student could neglect to a great extent the technical side of his college education for the cultural side, taking up the technical features as needed after graduation. Now such a very great deal is expected of the engineering graduate that that course is no longer possible; and indeed, after a rigorous 4-year college course

leading to a degree in engineering, most graduates still need much further engineering study, not to mention cultural studies. Some get advanced work in post-graduate courses, others in apprentice jobs, and many more neglect it entirely and drift to other fields of endeavor.

Perhaps the solution is a 5 or 6-year course, leading to a master of engineering degree, with the last 2 years patterned more after the English plan of independent work and personal supervision by a faculty member, but there again rises the necessity of many promising students to abandon study after 4 years to enter wage-earning fields. Some solution can and should be worked out; for without more time, it is impossible without neglecting other necessities, to do more than mention the things Dr. Karapetoff speaks of so earnestly.

Very truly yours,
Frank W. Godsey (A'30)
(Development Engineer, The Safety Car Heating and Lighting Co., New Haven, Conn.)

Reactive Volt-Amperes

To the Editor:

The lines in the usual diagrams illustrating power factor correction are vectors of volts and amperes although they may be labelled (convenience excusing such labelling) kilowatts and reactive volt-amperes.

A-c volt-amperes, whether watt or wattless, are not vector quantities, and they cannot be represented by vectors. It is only by a confusion of ideas that the operator j is applied to watts or to volt-amperes.

In the useful pamphlets (GET-191A and GEA-1508), recently published by the General Electric Company, the current vectors labelled "leading reactive kva" are shown lagging instead of leading, and lagging vectors are shown leading. Also we find the queerly muddled sentence: "This 'wattless' current or rkva may lag behind the voltage wave."

I suggest that the common practise of using the mongrel term "reactive power" be given up in favor of "reactive volt-amperes"; that the practise be adopted of stating plainly that the vectors labelled power and volt-amperes in power factor correction diagrams are vectors of volts or of amperes, as the case may be, and that, in such diagrams the convention common to other vector diagrams be followed of measuring angles of lead counter-clockwise.

Very truly yours,
F. M. Denton (A'08, F'28)
(Head of Electrical Engg. Dept., University of New Mexico, Albuquerque)

Karl S. Wagner Sought by Legation

Institute headquarters has been advised by the Roumanian Legation at Washington, D. C., that the "legation has very important information of a personal character and interest" for one Karl S. Wagner, whom the legation describes as an American engineer having traveled in Russia in 1913 in the employ of a New York company. Some time later he is reported to have moved to Michigan.

Members knowing the whereabouts of Engineer Wagner may do him a personal favor of some importance by conveying this information to him, that he may act accordingly.

Personal

W. T. BLACKWELL

W. T. Blackwell (A'22) general lighting representative of the Public Service Electric and Gas Company, Newark, N. J., has received reelection for the current year to the chairmanship of the Institute's technical committee on the production and application of light. Mr. Blackwell's early education consisted of private tutelage and preparatory school. In 1897 at the age of 18 he entered the construction department of the New York Telephone Company, New York, N. Y., remaining there until in 1902 when he became engineer in charge of street construction for the East River Gas Company, Long Island City. Mr. Blackwell has been associated with the lighting industry since 1905; in that year he was appointed assistant to the chief engineer of light and power, department of water supply, gas, and electricity, New York City, remaining in this position until 1915, when he was made illuminating engineer for the Benjamin Electric Manufacturing Company of New York City. After 2 years of service with this company, he was commercial and illuminating engineer for the Westinghouse Lamp Company, New York, for 4 years, and manager of the interior illumination department of the Westinghouse Electric and Manufacturing Company for one year. During the past 10 years he has been general lighting representative of the Public Service Electric and Gas Company. He has contributed many technical papers on illumination. Among the societies of which he is a member are: Illuminating Engineering Society, National Electric Light Association, National Safety Council, The American Society of Municipal Engineers, Newark Safety Council, and Essex Electrical League. Mr. Blackwell has served on the Institute's committee on the production and application of light since 1924, and since 1931 has been its chairman, thus automatically becoming a member of the Institute's technical program committee.

W. R. Whitney (A'01) organizer and for 32 years director of the research laboratory of the General Electric Company, Schenectady, N. Y., retired from that position owing to poor health on November 1, 1932. He was succeeded by Dr. W. D. Coolidge (A'10) formerly senior associate director of the laboratory. Doctor Whitney continues as vice-president in general charge of research. The research laboratory was established in 1900, and in that year Doctor Whitney came from Massachusetts Institute of Technology where he was an instructor, to be in charge of the research work. At that time the laboratory was in an old barn which was used by the late Dr. C. P. Steinmetz as a private laboratory. A few months later a small building at the General Electric works was secured. The expansion of the laboratory followed the development by Doctor Whitney of a new type of incandescent electric lamp, and since 1903 the laboratory has grown rapidly. By 1920 the laboratory's staff had grown to more than 300 persons, about half of whom were trained scientists; the value of this laboratory has long been recognized by the electrical industry. Among the many honors which Doctor Whitney has received was the Franklin Medal of the Franklin Institute on May 20, 1931. This award is made to "workers in physical science or technology without regard to country, whose efforts in the opinion of the administering committee on science and arts, have done most to advance a knowledge of physical science or its application." Doctor Whitney was assistant and later non-resident professor of theoretical chemistry at Massachusetts Institute of Technology, and is a member of the corporation of this institution

W. R. WHITNEY

A. LeRoy Taylor (M'28), head of the department of electrical engineering, University of Utah, Salt Lake City, has been appointed chairman of the technical program committee for the 1933 Pacific Coast Convention of the Institute to be held in Salt Lake City during the summer of 1933. He was born at Logan, Utah, in 1887. He received the degree of B.S. in E.E. in 1907 from the University of Utah and the degree of master of science in engineering in 1918

from the University of Michigan, specializing in mechanical engineering. During 1910 and 1911 he was in the testing department and the standardizing laboratory of the General Electric Company at Schenectady, N. Y., thereafter being instructor in electrical engineering at the University of Utah for a one-year period. Following this he spent 2 years in business, returning to the University of Utah in 1914 and remaining there since that time. He has been assistant and later associate professor of mechanical engineering at this institution, and since 1928 has been head of the department of electrical engineering. Professor Taylor has served the Utah Section as a member of its executive committee 1930–31, secretary 1931–32, and chairman 1932–33. He has also been chairman of the Utah Section of The American Society of Mechanical Engineers and has been secretary of the Engineering Council of Utah.

D. E. Renshaw (M'29) in charge of the petroleum mining section of the general engineering department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., recently received reappointment as chairman of the Institute's technical committee on applications to mining work. Mr. Renshaw was born in Hennessey, Okla., in 1891. After completing his local high school course, he attended the University of Oklahoma, at Norman, from which he was graduated in 1914 with the degree of B.S. in E.E. Between 1912 and 1914 he was electrician at this university. Upon graduation he was on the student course of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., for a year. From 1915 to 1917, he was in the railway

D. E. RENSHAW

engineering department of that company. He then left to join the United States Navy, which he served for 2 years. In 1920 he returned to Westinghouse and remained in the railway equipment engineering department until 1923, after which for 2 years he represented the Westinghouse company in France and Spain, supervising erection of the car and locomotive equipment on the Paris-Orleans Railway and the Spanish Northern Railway. In 1925 he returned to the railway equipment engineering department of the Westinghouse company. Since 1928 he has been section engineer in charge of the mining section, general engineering department and for the past year has had charge of the petroleum section, also. Mr. Renshaw has served the Institute's committee on applications to mining work for the past 3 years and since 1931 has been its chairman. His other A.I.E.E. committee work has included membership on the technical program and standards committees since 1931.

W. D. Coolidge (A'10) formerly senior associate director of the research laboratory of the General Electric Company, Schenectady, N. Y., was appointed on November 1, 1932, as director of this laboratory to succeed Dr. W. R. Whitney (A'01) who

W. D. COOLIDGE

retired on that date. Doctor Coolidge is a native of Hudson, Mass. He studied at the Massachusetts Institute of Technology and the University of Leipzig. Since 1905 he has been active in the research work of the General Electric Company, becoming assistant director of the laboratory in 1908 and associate director in 1928. A personal item mentioning some of the achievements of Doctor Coolidge was given in Electrical Engineering for March 1932, p. 210–11, in connection with his winning the Washington award for 1932.

J. H. Hamilton (A'28), associate professor of electrical engineering at the University of Utah, Salt Lake City, has been appointed chairman of the student activities committee for the 1933 Pacific Coast Convention to be held in Salt Lake City. He was born at Los Angeles, Calif., in 1904 and graduated from the California Institute of Technology at Pasadena. After engaging as technical assistant on lightning research for the Union Oil Company of California and the General Petroleum Corporation during 1926 and 1927, he became technical assistant for Kobe, Inc., Los Angeles, Calif., being engaged in the design of a magnetically controlled heat treating furnace. He was then for a while teaching fellow at the California Institute of Technology, and secured his doctor's degree from this institution in 1928. He is now Student Branch counselor at the University of Utah and an ex-officio member of the Institute's committee on student branches. For the year 1931–32 he was chairman of the North West districts committee on Student activities and a member of the excutive committee for this district. He is now a member of the executive committee of the Utah Section.

Eugene Caldwell (A'26), formerly chief mechanical engineer for the Central Public Service Corporation, Chicago, Ill., now is general manager of the Wrought Washer Manufacturing Company. Mr. Caldwell was editor-in-chief of *Industrial Power* for several years. He graduated from Ohio State University, Columbus, in 1922, and later took a special course at Massachusetts Institute of Technology, Cambridge, Mass. He is a member of the executive committee of the Institute's Chicago Section and chairman of the publicity committee of this Section. He is a member of The American Society of Mechanical Engineers, the publication committee of the Society of Industrial Engineers, and various committees of the National Electric Light Association. He is coauthor of a new textbook "American Industries," being used by New York University, and has contributed many articles to the technical press.

C. E. Stephens (M'22) formerly commercial vice-president and northeastern district manager of the Westinghouse Electric & Manufacturing Company, at New York, N. Y., was named vice-president. Mr. Stephens has been connected with the Westinghouse company since 1900, and with the New York office since 1917, having been appointed manager of the supply department in that year and later being made manager of the central station division, and in 1925 manager of the company's New York office. In 1930 he was elected commercial vice-president. He was at one time vice-president of the Illuminating Engineering Society. He has been active for many years in the A.I.E.E. and at present is a director of the Institute, chairman of the finance committee, and a member of several other of the Institute's committees.

C. H. Douglas (M'18) for some 12 years a St. Louis engineering-sales representative of various electrical manufacturing concerns now has become sales manager of the Industrial Products Sales Corporation, St. Louis. Mr. Douglas is a native of Walnut Ridge, Ark. (Feb. 5, 1886) graduated from the University of Arkansas in 1911 with degree of Bachelor of Science in electrical engineering, immediately after which he became associated with the Union Electric Light & Power Company of St. Louis; he became distribution engineer of that company in 1916. In June 1915 the University of Arkansas awarded him the degree of Electrical Engineer in recognition of advanced work completed.

H. H. Barnes, Jr. (A'00, M'04, F'13), vice-president of the General Electric Company, New York, N. Y., has been appointed chairman of the electrical industries and general machinery group of the Emergency Unemployment Relief Committee of

New York City, engaged in raising funds for unemployment relief during the winter 1932–3. This division, which is organizing 100 major trade groups through which funds will be solicited from employers, employees and employees' associations, last year raised more than $10,000,000 to finance "made" work and direct relief for the jobless. Last year Mr. Barnes headed the activities of the electrical industries for this committee.

C. M. LEAR (M'31) has been appointed to serve as an instructor in the physics department of the University of Florida, Gainesville. Mr. Lear is a native of Charlottesville, Va. (Nov. 21, 1907); in 1930 he graduated from the University of North Carolina with the degree of Bachelor of Science in electrical engineering. For advance work he expects to receive in June 1933 from this same university his Master's degree in physics. He spent 2 years as a student engineer in the General Electric test department, Schenectady, N. Y. (1928–9 and 1930–1).

F. H. KNAPP (A'28), who was assistant field engineer, area of the New York Telephone Company, for the Bell Telephone Laboratories, Inc., New York, N. Y., and later was located at St. Louis, Mo., engaged on work for the Southwestern Bell Telephone Company, now has returned to the Bell Telephone Laboratories, Inc., at New York, as field engineer, area of the Southwestern Bell Telephone Company. Mr. Knapp secured his E.E. degree from Rensselaer Polytechnic Institute in 1926.

F. W. SMITH (A'05, M'12), who early this year became president of the New York Edison Company and the United Electric Light and Power Company, has been elected a member of the board of trustees of the Consolidated Gas Company, New York, N. Y. A personal item, outlining Mr. Smith's career, was given in ELECTRICAL ENGINEERING for March 1932, p. 210.

E. W. FELLER (A'27) was recently transferred from the operating department of the Pennsylvania Water and Power Company at Holtwood, Pa., to the operating department of the Safe Harbor Water Power Corporation, Safe Harbor, Pa. Mr. Feller had been with the Pennsylvania Water and Power Company since 1924.

G. R. ANDERSON (A'22, M'29) in charge of the induction motor section of Fairbanks Morse & Company, Beloit, Wis., during the past year, recently was appointed chief engineer of the electrical division of the company.

C. J. HUBER (A'13) formerly manager of the product engineering division of Cheny Brothers, South Manchester, Conn., is now engaged on special work with the U.S. Testing Company, Hoboken, N. J.

H. R. KELLY (A'28), formerly statistician in the quality department of RCA-Victor, Inc., Camden, N. J., is now administration head of the engineering department of this company.

W. H. POLLARD (A'24) formerly an electrical engineer at the Indianapolis, Ind., works of Fairbanks Morse & Company, now is located in the Beloit, Wis., works of this company in the capacity of designing engineer.

Obituary

R. F. SCHUCHARDT (A'03, M'09, F'12, and past-president) chief electrical engineer of the Commonwealth Edison Company, Chicago, Ill., died in Boston, Mass., on October 25, 1932. Mr. Schuchardt had long been considered one of the foremost engineers of the United States. He was born in Milwaukee, Wis., in 1875, and in 1897 graduated from the electrical engineering course of the University of Wisconsin. Following graduation he spent a short period with the Janesville (Wis.) Electric Light and Power Company, later in that year he joined the staff of Meysenburg and Badt, Chicago, Ill., as engineering salesman. In July 1898, he entered the employ of the Chicago Edison Company (later the Commonwealth Electric Company and Commonwealth Edison Company) remaining with this organization until the time of his death. After a few weeks, first as substation operator and then in charge of the company's exhibit at the Trans-Mississippi Exposition, Omaha, Neb., he spent one year in the statistical department of the company. Between 1899 and 1906 he was in the testing department, through all stages from assistant to acting head. In 1906 he became engineer of electrical construction, having charge of this work for all stations and substations. In 1909 he was appointed electrical engineer of the company, and from that date to 1932 he has been intimately connected with the development of the company. He has made many contributions to technical literature since the presentation in 1897 of his first paper "Electricity Meters of Today" which attracted considerable attention. Mr. Schuchardt has long been active in the A.I.E.E., having served on many committees including the educational, power generation, power transmission and distribution, protective devices, standards, meetings and papers, executive, electrical machinery, law, Edison Medal, and public policy committees, as well as on the committee on code of principles of professional conduct. He has served as the Institute's representative on the U.S. national committee of the International Electrotechnical Commission, the administrative board of the American Engineering Council, the board of award of the John Fritz Medal, the Coffin fellowship and research fund committee, and on the joint committee of the engineering societies on participation of the engineering profession in the Century of Progress Exposition to be held in Chicago in 1933. From 1928 to 1929, Mr. Schuchardt was president of the Institute. He also was chairman of the Chicago Section of the Illuminating Engineering Society, chairman of the technical national section of the National Electric Light Association, member of the Western Society of Engineers, the Society for the Promotion of Engineering Education, and the Institution of Electrical Engineers of Great Britain. He has been chairman of the public affairs committee of the American Engineering Council, and in 1929 was a delegate to the World Engineering Congress in Japan.

EDWIN NASH SANDERSON (A'94, M'13, and Life Member) member of the firm of Sanderson and Porter, and president of the Federal Light and Traction Company, New York, N. Y., and of its 30 subsidiaries throughout the country, died November 9, 1932. He was born in Brooklyn, N. Y., in 1862. He attended Brooklyn Polytechnic Institute for 4 years and then attended Rensselaer Polytechnic Institute an additional 4 years, graduating with the degree of civil engineer in 1886. In 1887 he received the degree of M.E. from Cornell University. Between 1887 and 1896 he was with the Westinghouse Electric and Manufacturing Company, being an engineer at East Pittsburgh for one year, then engineer and salesman in New York for 5 years, manager of the New England district at Boston, Mass., for one year, and assistant to the general manager at East Pittsburgh for 2 years. In 1896 he resigned from the Westinghouse company; in this year the firm of Sanderson and Porter was formed and has since then remained active in the construction, management, and operation of electric railway, light and power properties. In 1910 his public utility holdings were incorporated into the Federal Light and Traction Company. Most of the major construction work of this company was performed by the firm of Sanderson and Porter, of which H. Hobart Porter (A'96, M'12, and Life Member), president of the American Water Works and Electric Company, Inc., New York, is the other senior member. One of Mr. Sanderson's major accomplishments was the construction in 1907 of one of the first hydroelectric projects in the Sierras, for the operation of the street railways of San Francisco, Calif. He was a member of The American Society of Mechanical Engineers, the Rensselaer Society of Engineers, the Cornell Society of Engineers, and Sigma Xi and Zeta Psi fraternities. He was a life member of the Board of Trustees of Cornell University. In 1925 Colgate University conferred upon him the honorary degree of Doctor of Law. Among his clubs were the University, City Midday, St. Bernard Fish and Game, Columbia Yacht, Town and Gown, and Cornell clubs, all of New York, the Union Club of St. John, N. B., and the Orchard Lake, Adirondack Mountain, and Westchester Country Clubs.

D. H. BRAYMER (M'15) head of the D. H. Braymer Equipment Company, Omaha, Neb., died October 29, 1932. He was born in 1883 at Hebron, N. Y. He secured his A.B. degree in 1906 from Cornell University, and his M.E. in E.E.

degree in 1908 from the same institution, having completed both mechanical and electrical engineering courses. During the summer of 1906 he was draftsman for the Morse Chain Company, Ithaca, N. Y., and during the summer of 1907 was electrical tester for the Electrical Testing Laboratories, New York, N. Y. He also held this latter position for a short time in 1908, becoming an engineer in the service and maintenance department of the New York plant of the Western Electric Company in that year. From 1909 to 1910 he was electrical engineer visiting and reporting on the Western Electric Company's power plant and telephone equipment in the capacity of publicity engineer. From 1910 to 1915 he was at Atlanta, Ga., on the staff of the *Southern Electrician* and succeeding magazines, being editor the latter part of this period. In 1915 he joined the McGraw-Hill Publishing Company as associate editor of the *Electrical World*, later becoming engineering editor, and then managing editor and coeditor. When the *Electrical Review* was purchased by the McGraw-Hill Company, Mr. Braymer was placed in charge of both the publishing and editorial policies of this magazine, which started under the name of the *Industrial Engineer*. In 1925, Mr. Braymer relinquished his editorial duties to organize the company which bears his name, specializing in consulting and sales work associated with power applications in industrial plants, large buildings, and power plants. He was at one time chairman of the Nebraska Section.

John L. Switzer (Enrolled Student) who recently received the Kruesi Improvement Prize awarded to senior students at the University of Tennessee, Knoxville, died October 1932. Mr. Switzer had been a student at the University of Tennessee, graduating from the electrical engineering course in June 1932 and had enrolled as a full-time graduate student for the coming year. The Kruesi prize, which he had just received, was established by Paul J. Kruesi of Chattanooga, for the benefit of engineering students at the University of Tennessee and is awarded each year to students of the graduating class who have been 3 years in attendance at the University of Tennessee. The award is made to that student of the senior class who by vote of the faculty of the college of engineering has made the most progress while a student, taking into consideration his preparedness, early opportunities, effort expended as a student, financial difficulties, ability, and activities outside of the curriculum. One prize is given in each of 4 engineering courses and covers the initiation fee and first year's dues in one of the following 4 engineering societies: American Chemical Society, The American Society of Mechanical Engineers, American Institute of Electrical Engineers and American Society of Civil Engineers. Mr. Switzer had been awarded membership in the Institute.

Frank T. Morrissey (A'16) who for the past few years has been president of F. T. Morrissey & Company, Inc., Dallas, Texas, died September 10, 1932. Mr. Morrissey was born at Waltham, Mass., in 1885, and in 1900 was apprentice to I. A. Nourse, electrical engineer, Westboro, Mass., receiving special instruction in power plant design and maintenance. After serving between 1903 and 1906 in the U.S. Army, he was assistant to the chief engineer of the Saxony Worsted Mills, Newton, Mass., for 2 years. Between 1908 and 1910 he was district superintendent of the Eastern Michigan Edison Company at Wayne, Mich., and at Ann Arbor, Mich., thereafter being in the engineering department of the Kansas City Electric Light Company, Kansas City, Mo., for one year. He was at one time president and general manager of the Warren Light and Power Company, Inc., and later general superintendent of the Plymouth Electric Light and Power Company, Plymouth, Ind. This was followed by other similar engagements. His own company, which he organized a few years ago, was engaged as selling representatives and engineers for manufacturers' equipment.

Ira Burnard Matthews (A'17) superintendent of the transformer department of the Toledo Edison Company, Toledo, Ohio, died suddenly at his work October 25, 1932. Mr. Matthews was born in Defiance, Ohio, in 1877. In his youth he came to Toledo where he obtained his early education, later attending Toledo University. He remained in this city the rest of his life, being employed in 1894 by the Western Union Telegraph Company, in 1896 by the Harrison Telephone Company, in 1897 by the Buckeye Pipe Line Company, in 1901 by the Toledo Western Electric Railway, in 1903 by the Pennsylvania Railroad Company, and since 1905 by the Toledo Railways and Light Company, now the Toledo Edison Company. Mr. Matthews served as foreman in the line department of this company until the organization of the transformer department, when he was made superintendent of this department. He had a wide experience in the general construction of telephone, telegraph, and low and high voltage electrical equipment.

Leonard G. Van Ness (A'04), consulting engineer of Memphis, Tenn., and Lodi, Wis., died on September 24, 1932. He was born at Lodi in 1869 and graduated from the University of Wisconsin with the degree of B.S. in E.E. in 1896. He was then employed in the machine shop of the Elgin National Watch Factory at Elgin, Ill., for one year and was then engaged in power line construction for a year. Between 1898 and 1902 he was electrical engineer with Emerson-McMillan Company engaged in central station work for companies in a number of different cities. In 1902 he became general manager of the Lincoln Gas and Electric Light Company at Lincoln, Nebraska. Later he was an official of the Memphis (Tenn.) Gas and Electric Company and remained active in public utility construction during his career. He had a wide experience in construction and rehabilitation of gas and electric properties and was considered an expert in analyzing the costs of operation and in conducting rate investigations.

Walter L. Woodmansee (A'23) chief electrician of the American Steel and Wire Company, South Works, Worcester, Mass., died recently as a result of severe burns received while making some electrical connections at the plant. Mr. Woodmansee was born in 1875 in Noank, Conn. Between 1896 and 1898, he was engaged in the construction and testing of electrical motors and generators at the Eddy Electrical Company, Windsor, Conn., and between 1898 and 1902 was installing and repairing motors and generators for the W. C. McIntire Company, Philadelphia, Pa. For 2 years following 1902, he undertook electrochemical experimental work for Rogers and Hite, Conshohocken, Pa., after which he spent 2 years rebuilding electrical machinery for Yearsley and Levene, Philadelphia, Pa. From 1906 until the time of his death, he held the position of chief electrician at the plant of the American Steel and Wire Company.

William Alexander Barrett (A'07) died on May 4, 1932, according to word recently received at the Institute headquarters. He was born at Wadesboro, N. C., in 1881, and was a graduate of the North Carolina Agricultural and Mechanical College in the electrical engineering course. Following graduation he was employed by the Union Electric Company of St. Louis, Mo., as meter inspector for one year, and later held a similar position with the Missoula Light and Water Company at Missoula, Mont. More recently, Mr. Barrett was electrician at the Puget Sound Navy Yard, Bremerton, Wash.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Anderson, F. C., 741 Oak Ave., Westfield, N. J.
Bohner, C. W., 620—22nd Terrace, Miami, Fla.
Brock, Geo., 1117 N. 15th St., Milwaukee, Wis.
Florez-Estrada, Jose, Avenida De La Paz 60, Reparto Alture-Rio Almendares, Marianao, Havana, Cuba.
Heiser, Edwin S., 413 Federal Bldg., St. Paul, Minn.
Jefferson, H. F., 633 Portola Ave., Glendale, Calif.
Katz, Henry, 2714 Wallace Ave., New York, N. Y.
Keller, Dr. Max Leo, Kornweg 8, Aarau, Switzerland.
Kirby, F. M., 22 E. 40th St., New York, N. Y.
McShane, Joe B., 810 Western Natl. Bldg., San Antonio, Texas.
Newman, Rexford C., 100 High St., St. Clairsville, Ohio.
Nimetz, John B., 3442 Sacramento St., San Francisco, Calif.
Olsen, V., P. O. Box 404, Shanghai, China.
Peterson, Alex., Central West Pub. Serv. Co., Omaha, Nebr.
Schatz, Nathan, 1845—52nd St., Brooklyn, N. Y.
Shen, C. Mayo, 18 an Check L8, Scott Rd., Shanghai, China.
Uline, Wm. A. Northern Elec. Co., Guy & Notre Dame Sts., Montreal, Que., Can.

Local Meetings

Past Section Meetings

Akron

Electrical Installations of Guggenheim Institute, by Prof. J. T. Walther, Akron Univ. Demonstration in airport lighting upon the arrival and departure of a tri-motor plane from Pittsburgh. Different Types of Wind Tunnels, by Dr. Theodore Troller, resident director of Guggenheim Institute. Demonstrations. Oct. 11. Att. 73.

Atlanta

The Engineer's Place in the Sun by Prof. W. E. Freeman, Univ. of Kentucky, vice-pres., A.I.E.E. Oct. 7. Att. 45.

Boston

Inspection trip through the new laboratories at Mass. Inst. of Tech. Oct. 19. Att. 90.

Cincinnati

Symmetrical Components, by A. W. Lewis, Westinghouse Elec. & Mfg. Co. Illustrations. Oct. 13. Att. 65.

Cleveland

Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres., A.I.E.E. Oct. 20. Att. 102.

Columbus

Air Conditioning Development, by R. E. Robillard, Frigidaire Corp. Oct. 28. Att. 36.

Connecticut

Seeing, by Dr. Matthew Luckiesh, Gen. Elec. Co. Joint meeting with Engrs. Club of Hartford. Sept. 29. Att. 200.

Design and Manufacture of Small Motors and Generators, by D. G. Shepherd, E. W. Borggrafe, and W. H. Haines, all of the Electric Specialty Co. Oct. 26. Att. 59.

Dallas

Overhead Conductor Vibration, by R. A. Monroe, Aluminum Co. of America. Illustrated. Oct. 17. Att. 61.

Denver

The Human Side of Constructing Engineers, by Prof. F. V. Bliss. Dinner. Oct. 21. Att. 24.

Detroit-Ann Arbor

The Public Utility Dollar—Where It Comes From and Where It Goes, by A. C. Marshall, Detroit Edison Co. Dinner. Oct. 18. Att. 160.

Fort Wayne

The Dependence of Air Transportation on the Electrical Engineer, by C. F. Green, Gen. Elec. Co. Illustrated. Oct. 11. Att. 115.

Houston

Industrial Engineering and the Electric Utilities, by L. K. Del'Homme, Houston Lighting & Power Co. Dinner. Oct. 26. Att. 13.

Indianapolis-Lafayette

Low Voltage Circuit Protection Without the Use of Fuses in Combination With the Deion Principle of Arc Extinction, by H. G. Nichols, Westinghouse Elec. & Mfg. Co. Illustrated. Oct. 18. Att. 72.

Kansas City

The Design and Purpose of Electric Dispatching Boards, by T. V. White, Amer. Automatic Elec. Sales Co.; Television, by G. L. Taylor, First National Television Co. Demonstrations. Oct. 25. Att. 65.

Lehigh Valley

Electrons at Work and at Play, by Phillips Thomas, Westinghouse Elec. & Mfg. Co. Demonstrations. Prize of $25 awarded to W. H. Lesser for the best local technical paper. Joint meeting with Engrs. Club, held at Hotel Traylor, Allentown. Oct. 14. Att. 650.

Los Angeles

The Industrial Aspect, by W. L. Moreland Moreland Motor Truck Co.; The Transportation Aspect, by Frank Carr, Pacific Elec. Co.; The Financial Aspect, by O. E. Monnette. Bank of America. Joint meeting with A.S.C.E., A.S.M.E., and A.I.M.E. Oct. 12. Att. 600.

Louisville

Inspection trip to Dix River Dam. Oct. 29. Att. 35.

Lynn

Chasing News With a Camera, by A. H. Blackington. Illustrated. Oct. 19. Att. 475.

Professor Nichols, of Tufts College, conducted an inspection trip to Nahant, Beach Bluff, and Salem to show local geological formations of particular interest. Oct. 29. Att. 35.

The Solar Eclipse, by Dr. D. H. Menzel, Harvard Observatory Staff. Nov. 2. Att. 800.

Madison

The Edgewater Plant, by W. S. Campbell, Wisconsin Pwr. & Lt. Co. Dinner. Nov. 2. Att. 42.

Memphis

Activities of the War Industrial Board, by Major E. C. Kelton, U.S. Engineers' Corps. Oct. 24. Att. 33.

Mexico

Annual banquet. Oct. 29. Att. 40.

Minnesota

Economics in Relation to Public Utilities, by Prof. J. M. Bryant, Univ. of Minnesota. Oct. 27. Att. 20.

New York

The Utility's Problem, by H. R. Searing, N. Y. Edison and United Elec. Lt. & Pwr. Co.; The Contractor's Problem, by Allen Coggeshall, Hatzell & Buehler, Inc. Power group meeting. Oct. 14. Att. 400.

Air Conditioning as a Potential Factor in National and World Economics, by W. H. Carrier, Carrier Engg. Co. Oct. 26. Att. 450.

World-Wide Telephony, by Bancroft Gherardi, Amer. Tel. & Tel. Co. Communication group meeting. Nov. 1. Att. 525.

Niagara Frontier

Rational Control of Motor Starting Currents, by R. T. Henry, Buffalo, Niagara & Eastern Pwr. Co. Oct. 21. Att. 65.

Oklahoma City

Vibration of Overhead Conductors, by R. A. Monroe, Aluminum Co. of Amer. Oct. 20. Att. 54.

Philadelphia

Adventures in Science, by E. L. Manning, Gen. Elec. Co. Oct. 10. Att. 125.

Pittsburgh

Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres., A.I.E.E. Oct. 19. Att. 114.

Pittsfield

Japan, China, and the White Man, by Upton Close. Nov. 1. Att. 1100.

Portland

Annual dinner with six speakers. Joint meeting with N.E.L.A. Oct. 18. Att. 57.

Providence

General Electric Oil Furnace, by F. A. Durkin, Gen. Elec. Co. Oct. 11. Att. 60.

The Narragansett Electric Distribution System, by Orie Van Rye, New England Pwr. Engg. and Serv. Corp. Nov. 9. Att. 60.

St. Louis

Oil-Filled, Self-Cooled Transformers by Temperature, by H. B. Keath, Wagner Elec. Corp. Oct. 19. Att. 69.

San Antonio

San Antonio's New Automatic Telephone System, by B. D. Hull, Southwestern Bell Tel. Co. Inspection trip through the plant. Sept. 26. Att. 142.

Vibrations in Overhead Conductors, by R. A. Monroe, Aluminum Co. of Amer. Demonstrations. Oct. 18. Att. 42.

San Francisco

The European Viewpoint, by Frank Copley; Proposed Boulder Dam Transmission Line, by Bradley Cozzens, Bureau of Pwr. & Lt. of the City of Los Angeles. Dr. J. F. Carroll explained the laboratory equipment and tests to be witnessed. Oct. 19. Att. 250.

Saskatchewan

Banquet. Joint meeting with E.I.C. Oct. 21. Att. 22.

Schenectady

Methods of Obtaining Colored Motion Picture Films, by J. G. T. Gilmour, Gen. Elec. Co. Oct. 6. Att. 125.

Sharon

Electrons at Work and at Play, by Dr. Phillips Thomas, Westinghouse Elec. & Mfg. Co. Film—"Dynamite." Oct. 21. Att. 230.

Springfield

Total Eclipses of the Sun, by B. V. K. French, Amer. Bosch Magneto Corp. Illustrated. Oct. 10. Att. 71.

Toledo

Executive committee meeting. Oct. 6. Att. 8.

Soviet Russia, by Mr. Buchenburg, Electrical Autolite Co. Oct. 12. Att. 18.

Fundamentals of Magnetism, by W. W. Cummins, Toledo Edison Co.; Effects of Electric Shock, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres., A.I.E.E. Oct. 21. Att. 160.

Toronto

Recent Developments in Air Breaker Switching, by W. Gilson, Eastern Pwr. Devices. Oct. 14. Att. 90.

The Foundations of Science, by W. F. Sutherland, Toronto Hydroelectric System. Oct. 28. Att. 50.

Washington

Light, by Prof. L. D. Bliss, Bliss Electrical School. Oct. 11. Att. 90.

Worcester

Illumination, by W. E. Haycock, Gen. Elec. Co.; Radio, by Prof. H. H. Newell, Worcester Poly. Inst.; Air Conditioning, by E. D. Learned, Worcester Elec. Lt. Co.; Electric Heating of Buildings, by W. A. Sutphen, New England Pwr. Engg. & Serv. Corp.; Telephone, by J. W. Kidder, New England Tel. & Tel. Co. Dinner meeting. Oct. 18. Att. 43.

Future Section Meetings

Boston

December 13—Lightning Arrestors, by Messrs. Corney and Haynes.

January 10, 1933.—International Communication.

Cleveland

December 15—Submarine Treasure Hunting With Underwater Lamps, by E. W. Beggs, Westinghouse Lamp Co. Joint meeting with Ill. Engg. Soc., at Westinghouse Lighting Studios Edgewater Park.

January 19, 1933—Social meeting.

Detroit-Ann Arbor

December 13, at Detroit, Mich.—Electric Motors and Their Applications, by A. M. Dudley, Westinghouse Elec. & Mfg. Co.

January 17, 1933, at Detroit, Mich.—Extending Our Frontiers Through Research and Engi-

neering, by H. P. Charlesworth, pres., A.I.E.E., vice-pres., Bell Tel. Labs., Inc.

Fort Wayne

December 7, at Chamber of Commerce.—Design and Application of Demand Meters, by H. M. Witherow, Gen. Elec. Co.; Performance Calculations for Special Stationary Apparatus, by M. L. Schmidt, Gen. Elec. Co.

January 17, 1933, at Home Tel. & Tel. Auditorium.—Dial Controlled Robots, by H. M. Bruckart, Home Tel. & Tel. Co.; A New Development in Oven Control, by R. M. Hartigan, Gen. Elec. Co. Inspection of the Fort Wayne Telephone Exchange.

Lehigh Valley

December 9, at Berkshire Hotel, Reading, Pa.—Three Years Progress in Field Investigation With Artificial Lightning, by K. B. McEachron, Gen. Elec. Co.; Reversed Refrigeration for House and Water Heating, by G. Wilkes, W. F. Barstow Co.

Pittsfield

December 6—Rovings of a German Sea Raider, by Captain Julius Lauterbach.

December 20—Theory of the Expanding Universe, by Dr. Harlow Shapley.

January 3, 1933—By Air to Inca Land, by Robert Shippee.

January 17, 1933—Modern Railway Electrification—With Special Reference to Pennsylvania System, by J. V. B. Duer, Pennsylvania RR. Co.

Toledo

December 16—Lighting the Modern City, by L. A. S. Wood, Westinghouse Elec. & Mfg. Co.

January 13, 1933—Air Conditioning, by H. B. Matzen, Carrier Corp.

Toronto

December 16—Applications of Synchronous Motors, by Leech-Porter.

January 13, 1933—Coordination of Insulation, by W. W. Lewis.

January 27, 1933—Astronomy and the Dunlap Observatory, by Prof. Chant, Univ. of Toronto

Past Branch Meetings

University of Alabama

The Commercialization of the X-Rays, by W. K. Price, student. Oct. 16. Att. 29.

The Power Distribution of Transit Lines, by F. B. Gaines, student. Oct. 24. Att. 24.

University of Arkansas

Benefits of Membership in the A.I.E.E., by Dean W. N. Gladson. Oct. 6. Att. 37.

A review of the papers and events at the Conference on Student Activities, held at the University of Oklahoma, was given by several students. Oct. 27. Att. 32.

The American Engineer in Russia, by G. Smith, student; Investigation of Single Energy Transients, by W. D. Thornberry, student; Engineering From the Sales Viewpoint, by C. E. Bradley, Gen. Elec. Co. Nov. 3. Att. 34.

Armour Institute of Technology

Discussion of Branch activities. Oct. 7. Att. 31.

Air Conditioning, by M. J. Maiers, Central Station Institute. Illustrated. Oct. 21. Att. 35. Motion pictures. Nov. 4. Att. 30.

University of British Columbia

Western Electric Speech Input Equipment, by W. Smith, student; Photo-Telegraphy, by L. Rader, student. Oct. 13. Att. 13.

Polytechnic Institute of Brooklyn

The Applications of the Photoelectric Cell in the Holland Tunnel, by Prof. Robin Beach. Refreshments. Nov. 2. Att. 65.

California Institute of Technology

M. S. Hodge, chmn., gave a report of the Pacific Coast Convention held in Vancouver. Prof. R. W. Sorensen, counselor, gave a summary of the work carried on by the A.I.E.E. Oct. 14. Att. 26.

H. C. Fracker, Bell Tel. Labs., Inc., gave a demonstration and lecture of the newly developed vertical cut phonograph records, recording, and amplification system. Oct. 20. Att. 300.

University of California

The Application and Operation of the Teletypewriter, by R. Tibbetts and V. Tonjes, students. Motion pictures. Sept. 21. Att. 51.

Initiation banquet. Problems Found in the Engineering, Social, and Economic Fields, by Dr. Ira B. Cross. Sept. 23. Att. 57.

Carnegie Institute of Technology

The Development of the Carnegie Tech. Branch of the A.I.E.E., by Prof. G. Porter, counselor; Place of an Engineer in Engineering Society, by Dr. W. R. Work; Benefits I Have Derived From Membership in the A.I.E.E., by Dr. C. E. Skinner, Westinghouse Elec. & Mfg. Co. Oct. 17. Att. 27.

Testing Railroad Tracks by Means of the Sperry Railroad Car, by Dr. W. B. Kouwenhoven, Johns Hopkins Univ., vice-pres., A.I.E.E. Oct. 19. Att. 90.

Case School of Applied Science

Prof. J. R. Martin described his work in connection with the eclipse. Oct. 21. Att. 31.

Catholic University of America

Election of officers: J. Springman, pres.; R. Bourne, vice-pres.; T. J. Nally, secy.; F. Hurson, treas. Oct. 4. Att. 20.

Clemson Agricultural College

Executive meeting. Oct. 4. Att. 51.

A Modern European Power Plant, by M. G. Miller, student; The Development of Electrical Machinery in the U.S., by H. A. Clayton, student; current events, by E. B. Shaw, student. Oct. 25. Att. 34.

Colorado Agricultural College

Prof. G. Z. Dimitroff outlined his trip to New England to photograph the total eclipse of the sun. Joint meeting with A.S.M.E. branch. Oct. 24. Att. 26.

University of Colorado

The Construction, Management, and Functions of the A.I.E.E., by Prof. W. C. DuVall, counselor, and Prof. M. S. Coover, District secy. A.I.E.E. Oct. 5. Att. 53.

My Vacation Tour of France, Switzerland, Germany, and England on a Bicycle, by J. M. Evans, student. Illustrated. Joint meeting with A.S.M.E. Branch. Oct. 19. Att. 52.

Cornell University

Political Issues and the Stock Market, by J. W. McWilliams, student; The Making of Lateral Cut Records on Aluminum Disks, by J. W. Conn, student. Oct. 28. Att. 25.

University of Denver

Electrical Engineering and Senior Branch of A.I.E.E., by Prof. R. E. Nyswander, counselor. Oct. 11. Att. 20.

Inspection trip through the terminal station and two substations of the Public Service Co. of Colo. Att. 12.

University of Detroit

Lighting of the Campus and Power Factor Correction, by Prof. H. O. Warner, counselor. Films—"Vacuum Tube Synchronization," "Synchronizing Machine Construction." Oct. 27. Att. 42.

Duke University

The Advantages and Disadvantages of Double Conductor Transmission Lines, by D. E. Cook, student; The Expansion of Electrical Engineering Fields, by W. J. C. Brown, student. Oct. 18. Att. 27.

Fallacies of Mathematics, by Wm. Karpinsky, student; The Engineer's Place in the Sun, by Prof. W. E. Freeman, Univ. of Kentucky, vice-pres., A.I.E.E. Nov. 3. Att. 33.

University of Florida

The Florida Portland Cement Plant at Tampa, Fla., by J. B. Smith, student; Things of Interest in the Bell Telephone Laboratories, by E. L. Stuhrman, student. Oct. 18. Att. 40.

University of Idaho

Films—"Manufacturing Mazda Lamps," and "Power Transformers." Dinner. Oct. 4. Att. 26.

University of Illinois

The Theory of Oscillatory Circuits, by Mr. Veach, student. Film—"The Electric Ship." Oct. 12. Att. 127.

University of Iowa

R.O.T.C. Summer Camp Life, by T. R. MacDougall, student. J. W. Blessing elected secy. Oct. 5. Att. 31.

General discussion and inspection of the new dial telephone exchange. Oct. 12. Att. 32.

Dial Telephone Systems, by H. Hammond, student; Elimination of Radio Interference, by A. Shradel, student. Oct. 26. Att. 38.

Flood Lighting, by C. Bartholow, student; Guiding Airplanes by Radio, by Wm. Benineosa student. Nov. 2. Att. 36.

University of Kentucky

Election of officers: R. H. Gray, pres.; E. W. Graham, secy.-treas. Sept. 21. Att. 48.

Lehigh University

Airport Lighting, by W. D. Hickman, student; My Experiences at Harvard and M.I.T., by Prof. J. L. Beaver. Committees appointed. Oct. 7. Att. 50.

The Cosmic Ray, by Dr. R. A. Millikan, Calif. Inst. of Tech. Oct. 26. Att. 780.

Lewis Institute

Prof. F. A. Rogers, counselor, outlined the privileges and advantages of student enrolment in the A.I.E.E. Oct. 18. Att. 120.

Election of officers: I. R. Ekstrom, pres.; Walter Bohne, secy.-treas. Nov. 3. Att. 88.

Louisiana State University

Discussion. Nov. 3. Att. 21.

University of Louisville

Dix River Dam Electric Power Project, by Mr. Jefferson, student. Film—"Pathways of Progress." Nov. 7. Att. 23.

Michigan College of Mining and Technology

Prof. G. W. Swenson, counselor, outlined the advantages of membership in the A.I.E.E. Oct. 13. Att. 42.

Distribution, by I. H. Gronseth, Board of Water & Elec. Lt. Comm. Oct. 19. Att. 46.

Inspectioh trip to the Howell Motors Co. Oct. 26. Att. 17.

Ultra short wave radio demonstration. Nov. 2. Att. 41.

University of Michigan

Election of officers: J. M. Lyon, chmn.; G. Leland, vice-chmn.; I. J. Sattinger, secy.; D. J. Carr, treas. Film—"Nature's Frozen Credits." Oct. 17. Att. 54.

Milwaukee School of Engineering

Electric Sectional Drive for Paper Making Machinery, by E. H. Laabs, Cutler-Hammer Mfg. Co. Oct. 12. Att. 76.

University of Minnesota

Experiences at Oxford, by Fred Hovde. Oct. 12. Att. 110.

Mississippi State College

Discussion. Oct. 12. Att. 30.

University of Missouri

Synchronous Motors, by C. Haines and F. Hubbell, students. A. Coffman, student, outlined the Conference on Student Activities, held at the Univ. of Okla. Nov. 2. Att. 27.

Montana State College

X-Ray and Cathode Ray Tubes in Biological Service, by L. Ambrose; The Engineer in a Changing Society, by R. V. Bauer; Underground Conduit Construction, by J. Cromer; A Noiseless and Flameless High-Voltage Fuse, by Loran Eisele; Erecting Poles With Conductors Attached, by C. L. Grebe, all students. Oct. 13. Att. 86.

Welding Steel Structures, by Rex Wyman; A 115,000 Kw. Turbo-Alternator, by E. Rothfus; Radio and Television, by T. Degenhart and J. Lightfoot, all students. Oct. 20. Att. 89.

The Characteristics of Some Miniature Lamps, by D. A. Nauck; Highway Lighting, by J. Antonich; Visiting Butte's Greatest Industry, by M. Axelson; Further Research in Injuries From Electric Shock, by C. Bergland, all students. Oct. 27. Att. 95.

University of Nevada

Discussion. Oct. 7. Att. 7.

Newark College of Engineering

Members attended the George Washington Bicentennial celebration, sponsored by the joint professional engineering societies of Essex County, at which Roy V. Wright, editor of *Railway Age*, spoke on GEORGE WASHINGTON, THE ENGINEER. Oct. 19. Att. 25.

University of New Hampshire

Film—"Anthracite." Sept. 24. Att. 31.

TESTING PAPER FOR ELECTRICAL INSULATION, by H. T. Dickson; CORRECTING READINGS TAKEN ON SMALL POWER MOTORS, by A. E. Dogan; EDDY CURRENTS, by H. W. Feindel; E. Horne covered the question box in Electric Journal, all students. Oct. 1. Att. 27.

NOTHING MORE MODERN, by H. W. Machon; AN ORDEAL BY WATER and EDDY CURRENTS, by O. Abbiatti; MECHANICAL VIBRATION RESEARCH, by A. F. Allen; THE CLOCK ON THE MANTEL, by E. L. Huse, all students. Oct. 15. Att. 32.

TYPES OF SUPPLY FOR THREE WIRE SYSTEMS, by C. W. Quimby; FUSING THE NEUTRAL OF A THREE WIRE SYSTEM, by H. W. Hamm; THE HOMOPOLAR OR UNIPOLAR GENERATOR, by R. C. Loeschner; GUN RECOIL CONTROL, METALIZED WOOD, and INVISIBLE WIRE HAIR, by M. H. Sargent, all students. Oct. 29. Att. 29.

College of the City of New York

INDUSTRIAL CONTROL PROBLEMS, by O. H. Diefendorfer, Gen. Elec. Co. Oct. 20. Att. 51.

Discussion. Oct. 27. Att. 29.

New York University

Prof. H. N. Walker, counselor, outlined future plans. Oct. 14. Att. 18.

THE PHOTOELECTRIC CELL, by Mr. Zdanowitz, student; PUSH-PULL AMPLIFIERS, by Mr. Christie, student. Oct. 28. Att. 20.

North Carolina State College

THE ELECTRIC POWER DEVELOPMENT IN SYRIA, by J. R. Salem, student; ENGINEERING TOPICS OF THE DAY, by C. M. Smith, Jr., student. Oct. 18. Att. 42.

COUNTING SALMON IN ALASKA, by J. S. Culbertson, student; ENGINEERING TOPICS OF THE DAY, by C. M. Smith, Jr., student; TECHNOCRACY, by F. E. Brammer, student. Nov. 1. Att. 35.

University of North Carolina

THE AIMS, FUNCTIONS, AND ORGANIZATION OF THE A.I.E.E., by Prof. J. E. Lear, counselor; THE A.I.E.E. CONVENTION AT CLEVELAND, by Prof. E. W. Winkler. Oct. 13. Att. 50.

University of North Dakota

CAISSONS, by Boyd Begg, Raymond Concrete Pile Co. Oct. 5. Att. 21.

Talk by P. J. Montgomery, Northern States Pwr. Co. Oct. 19. Att. 21.

Film—"Electricity Goes to Sea." Nov. 3. Att. 17.

University of Notre Dame

ELECTRICAL APPLICATIONS TO MUNICIPAL GOVERNMENT, by E. A. Quallis, supt., City Electrical Dept. of South Bend. Oct. 19. Att. 70.

MAKING A LIVING WITH AN ENGINEERING EDUCATION, by J. P. Kennedy; PATENTS—HOW TO GET ONE AND THE COST, by Leo Hanlon, student; ELECTRIFICATION OF THE GREAT NORTHERN RAILWAY, by John Land, student; P. McCaffary, student, gave the bi-weekly review of current engineering news. Nov. 2. Att. 54.

Ohio State University

HISTORY AND FOUNDING OF THE A.I.E.E., by Prof. F. C. Caldwell, counselor; THE ENGINEER IN INDUSTRY, by Prof. Bibber. Oct. 13. Att. 40.

Ohio University

Prof. A. A. Atkinson, counselor, and J. Hoskinson, chmn., outlined the advantages of membership in the A.I.E.E. Oct. 10. Att. 23.

REMOTE CONTROL OF SHIPS FROM LAND STATIONS, by W. Cooper and C. Eddy, students. Oct. 19. Att. 14.

HOW ELECTRICITY RECEIVED ITS START IN ATHENS, by Prof. A. A. Atkinson, counselor. Nov. 2. Att. 15.

University of Oklahoma

Prof. F. G. Tappan, counselor, explained student enrolment in the A.I.E.E. Oct. 5. Att. 18.

Oregon State College

ACCEPTANCE TEST OF THE ROCK ISLAND HYDRAULIC UNIT, by J. F. Spease, Gen. Elec. Co. Oct. 20. Att. 39.

Pennsylvania State College

Smoker. Oct. 5. Att. 60.

Rensselaer Polytechnic Institute

CONSTRUCTION OF THE NEW TRANSMISSION LINE BETWEEN ALBANY AND WESTCHESTER COUNTIES, by A. G. Strickrott, N. Y. Pwr. & Lt. Corp. Oct. 18. Att. 350.

Rhode Island State College

Film—"Nature's Frozen Credits." Oct. 13. Att. 25.

MICHAELSON'S EXPERIMENTS ON THE VELOCITY OF LIGHT, by Prof. Wm. Anderson, counselor. Oct. 20. Att. 16.

INDUSTRIAL APPLICATIONS OF THE THYRATRON TUBE, by E. A. Hancock and A. J. Moore, both of the General Elec. Co. Nov. 2. Att. 175.

Rutgers University

Discussion. Oct. 4. Att. 19.

PRACTICAL TESTING OF TELEPHONE CABLES, by L. M. Leeds, Amer. Tel. & Tel. Co. Oct. 18. Att. 19.

Film—"Conowingo." Nov. 1. Att. 41.

University of Santa Clara

INDUSTRIAL ACHIEVEMENTS IN OTHER COUNTRIES, by Warren McBride. Joint meeting with A.S.M.E. Branch. Oct. 7. Att. 66.

University of South Carolina

TELEVISION, by G. W. Arrants; THE LINER THAT CANNOT ROLL, by T. J. Bennett; ELECTRIC AIDS TO MEDICINE, by S. A. Black, all students. Oct. 10. Att. 33.

NIGHT LIGHTING FOR OUTDOOR SPORTS, by D. W. Cardwell; RADIO AND DYNAMITE FIND EARTH'S SECRET RICHES, by T. H. Coughman; ELECTRIC SHIP CALIFORNIA, by C. L. Bradley, all students. Oct. 17. Att. 34.

MORE POWER TO CANADA, by R. F. Cuthbertson, student; PHOTOELECTRIC CONTROL OF PAPER CUTTER REGISTER, by N. J. Christensen, student. Oct. 24. Att. 35.

RADIO ACTIVITY, by M. Garris; WELDING, by L. Folson, OVERSEAS TELEPHONY, by A. G. Daniels, all students. Oct. 31. Att. 33.

South Dakota State School of Mines

Discussion. Oct. 12. Att. 25.

Albert Hall elected vice-chmn., and Charles Reed elected secy.-treas. Oct. 21. Att. 26.

University of Southern California

THE ESSENTIALS OF A SUCCESSFUL ENGINEER, by Mr. Rowley, Los Angeles Bureau of Water and Power. Sept. 21. Att. 26.

ENGINEER AND HIS SOCIAL ASPECTS, by Dean Bacon. Sept. 28. Att. 20.

HIGH HEAD, REMOTE CONTROL, PUMPING STATION AT BOULDER DAM, by W. F. Grimes, Westinghouse Elec. & Mfg. Co. Oct. 5. Att. 29.

Banquet. Oct. 13. Att. 24.

Southern Methodist University

RECENT DEVELOPMENTS IN THE METERING OF ELECTRICAL ENERGY, by M. P. Jones, student. Oct. 19. Att. 8.

Stanford University

Events at the Pacific Coast Convention, held in Vancouver, outlined by several students. Oct. 11. Att. 30.

Stevens Institute of Technology

ROLLS ROYCE TYPE R ENGINE USED IN THE SCHNIEDER TROPHY RACES, by Prof. E. Fezandie. Oct. 7. Att. 44.

Syracuse University

CRYSTAL CONTROL OF THE VACUUM TUBE, by A. Adams, student; RADIO BEACONS, by C. P. Bower, student. Oct. 11. Att. 23.

POWER TRANSMISSION, by J. S. Brzostek, student; X-RAYS, by R. Bradshaw, student. Oct. 18. Att. 23.

POWER TRANSMISSION AND DISTRIBUTION IN SYRACUSE, by A. Carley, student; STATIC ELIMINATION IN RADIO SETS, by C. M. Crysler, student. Oct. 25. Att. 20.

Inspection trip to hydroelectric power plants at Salmon River and Oswego. Nov. 1. Att. 21.

HARMONIC ANALYSIS, by Prof. C. W. Henderson, counselor; ELECTRICAL HOME AT PRESENT, by L. E. Dawley, student; ELECTRICAL HOME OF THE FUTURE, by N. F. Emig, student. Nov. 8. Att. 21.

University of Tennessee

Discussion of future activities. Oct. 5. Att. 20.

Films—"Sugar Cane Industry in Cuba" and "Construction of the Panama Canal." Oct. 19. Att. 25.

CHARACTERISTICS OF A MERCURY VAPOR TUBE, by A. C. Seletzley, and S. T. Shevki, presented by Wiley Patton, student. Review of current events given by Mr. Lerch, student. Nov. 2. Att. 14.

Texas A. & M. College

Election of officers: G. H. Samuels, chmn.; W. E. Steele, vice-chmn.; J. I. Walton, secy.-treas. Oct. 4. Att. 80.

WHY MODERN HIGH SPEED RAILWAY SERVICE IS POSSIBLE, by H. B. Yarbrough; STRAY LOSSES OF A D.C. DYNAMO, by J. K. Jones; PERMEABILITY TUNING OF BROADCAST RECEIVERS, by C. C. Johnston; AN ULTRA SHORT WAVE TRANSMITTER, by G. C. Hutcheson; LIGHTNING PROTECTION, by A. J. Ismeal, all students. Oct. 11. Att. 26.

Film—"Conowingo." Oct. 27. Att. 90.

Texas Technological College

THE AIMS AND PURPOSES OF THE STUDENT BRANCHES, by J. Preston Conner, student. THE ADVANTAGES OF A TECHNICAL EDUCATION, by Dr. Bradford Knapp. Oct. 5. Att. 29.

University of Texas

W. B. Hurt elected corresponding secy. Oct. 5. Att. 28.

SOME FUNDAMENTALS ON INDUCTIVE COORDINATION, by David Sussin, student. Oct. 13. Att. 12.

University of Utah

Film—"A Trip Through the G. E. Plant." Oct. 26. Att. 36.

NEW TRANSMITTER EQUIPMENT AT STATION KSL, by E. G. Pack, radio engr. at that station. Nov. 2. Att. 38.

University of Virginia

Discussion. Oct. 14. Att. 14.

THE ENGINEER'S PLACE IN THE SUN, by Dean W. E. Freeman, Univ. of Kentucky, vice-pres., A.I.E.E. Oct. 20. Att. 24.

Virginia Military Institute

ARMATURE AND STATOR WINDINGS, by N. W. Dingman; ELEVATOR SERVICE IN OUR MODERN SKYSCRAPERS, by J. T. Taylor; IMPROVING THE PRESTIGE OF THE ENGINEERING PROFESSION, by G. S. Bernard; THE STORY OF FREQUENCY, by C. E. Schoonover, all students. Sept. 23. Att. 111.

NOTHING MORE MODERN, by R. S. Singleton; ELECTRIC LOCOMOTIVES, by J. M. Troutt; MOTOR CAR DESIGN, by G. C. Wilson; GUIDING AIRPLANES BY RADIO, by T. R. Wise, all students. Oct. 1. Att. 106.

Virginia Polytechnic Institute

Film—"Conowingo." Oct. 13. Att. 168.

THE ENGINEER'S PLACE IN THE SUN, by Prof. W. E. Freeman, Univ. of Kentucky, vice-pres., A.I.E.E. Oct. 21. Att. 66.

HIGHWAY and STREET LIGHTING, by W. E. DeBrick; REVERSED REFRIGERATION, by G. Giles, Jr.; TOO MANY ENGINEERS, by E. H. Farley; COMMUNICATION AS AN AID TO TRANSPORTATION by J. L. Brown; PHILADELPHIA'S NEW ELECTRICAL STRUCTURE, by R. P. Haskins, all students. Oct. 27. Att. 42.

State College of Washington

General discussion. Oct. 14. Att. 25.

University of Washington

FREQUENCY MODULATION OF RADIO WAVES, by E. D. Scott, student. Oct. 13. Att. 25.

BUSINESS CONDITIONS AS THEY AFFECT THE STUDENT, by L. E. Karrer, Puget Sound Power & Light Co. Oct. 20. Att. 21.

Film—"Nature's Frozen Credits." Oct. 27. Att. 23.

West Virginia University

TAMING A TROPIC TORRENT, by R. H. Colborn; LONGEST TELEPHONE CABLE IN THE WORLD, by U. A. Chapman; IS RADIO MAKING US A RACE OF MORONS? by J. G. Henderson; TYPE 57 RADIO TUBE, by N. I. Hall; EXPERIENCE IN TESTING PORCELAIN, by J. E. Wallace; THERMOSTATIC CONTROL ON MOTOR CIRCUITS, by M. B. Tolley; LIFE OF BENJAMIN CARVER LAMME, by R. Marshall, all students. Oct. 10. Att. 22.

SYNCHRONOUS MOTOR EFFECT IN INDUCTION MOTORS, by F. Q. Brown; WAVE FREQUENCY METER, by G. F. LeFeure; CIRCUIT DIAGRAMS, by J. Millard; LITTLE WATER PASSES EAGLE PASS, by E. C. McMillan; S. S. MANHATTAN, by C. B. Sims; COMMUNICATION AT NATIONAL CONVENTION, by P. M. Vannoy; CONSTANT CURRENT STREET LIGHT CIRCUIT, by L. P. Lovett, all students. Oct. 17. Att. 26.

TESTING SURGE GENERATORS, by R. Caddock; BIOGRAPHY OF CHARLES P. STEINMETZ, by G. Henderson; W. VA. UNIVERSITY HEATING PLANT, by R. R. McCue; PEARL STREET GENERATING

PLANT, by E. J. Williams; PUBLIC ADDRESS SYSTEM, by W. D. Hall; MODERN LIGHTING IN INTERURBAN CARS, by L. H. Winger, all students. Oct. 24. Att. 24.

DESCRIPTION OF AN ALEXANDREAN ALTERNATOR, by N. I. Hall; 75-KV SUBMARINE CABLE FOR DEEPWATER STATION, by J. E. Wallace; POWER ELIMINATORS, by M. B. Tolley; DIESEL POWER STATIONS, by R. Marshall; HYDROGEN AS A COOLING MEDIUM FOR ELECTRICAL MACHINERY, by R. H. Colborn; TURBINE DESIGN HERE AND IN GREAT BRITAIN, by L. W. Hall; METHODS OF CONTROLLING THE SPEED OF INDUCTION MOTORS, by W. C. Monteith, Jr., all students. Oct. 31. Att. 25.

University of Wisconsin

Moving pictures. Oct. 19. Att. 28.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

Construction

ELEC. CONSTRUCTION ENGR with 10 yr practical experience in elec. construction on new and old buildings, including estimating, field engg. and designing. Have had complete charge of elec. construction on many buildings in New York City and can furnish the best of references. Available at once. A-850.

CONST. MAIN. ENGR, 36, married, factory layout installation, inventive, new ideas pertaining to elec. and steam mach. conveyors, switchboard design. Power plant layout and installation, const. transmission, also good in marine work. Location anywhere. D-1622.

E.E. GRAD., Ohio State, 1929, married, 29. Three yr communication training with Ohio Bell Tel. Co., including outside line and cable construction, subway, pole line, maintenance, installation and testing experience. Not afraid of hard work. References furnished. Available immediately and will go anywhere. D-1674.

GRAD. E.E., 29, five yr supervisory construction, design, estimating and field engg experience on super-power plants and substations; 4 yr industrial power plant operation. Elec. construction and maintenance experience; railway electrification construction experience. C-4428.

Design and Development

DISTRIBUTION, DESIGN OR MANUFACTURING ENGR, E.E. grad. 27, married. Six yr experience with Westinghouse on distribution, special and small transformer designs. Desires responsible position as transformer design, development or mfg. engr or e.e. for mfr., utility, holding company or where knowledge of big company's methods may be used. Available immediately. D-963.

E.E., univ. grad., elec. power experience, both design work and construction and maintenance work, desires position with power or mfg. organization offering permanent or temporary position in office or field. B-1923.

E.E., univ. grad., 34, single, 7 yr experience in drafting design, installation distribution networks, power companies and industrial plants. Five yr with communication engg in design, manufacture of testing equipment. Good mathematician, good draftsman. French, German, Spanish. Desires responsible position. Anywhere. D-1514.

E.E. GRAD., 33, 10 yr experience in the elec. industry, 8 yr actual experience on the design of motors and fans. Capable of assuming full responsibility for development of a-c and d-c motors and generators. Highest references. Middlewest preferred. C-5353.

ELEC.-MECH. ENGR with metallurgical knowledge. College grad. with post grad. study. Age 30, married. Westinghouse design training. Six yr experience design elec. circuits and mech. details of control apparatus, specialized in elevator equipment. Interested in alloy welding research. Location immaterial. Available on short notice. C-9638.

ELEC. AUTOMOTIVE ENGR, desires position with medium size manufacturer on design and development of automotive accessories. Have patented 19 automotive accessories. Ten yr experience and at present experimental and automotive engr on fleet of 2,300 trucks, etc. Technical education, age 32. Location New York or Philadelphia. D-1653.

E.E., 34, 10 yr experience covering design, cost estimating, and equipment specifications of power plants, industrial buildings, copper and oil refineries, substations and transmission lines. Also one yr as assist. research engr with cable co., and one yr as elec. tester with elevator co. Speak German. C-5473.

ELEC. DESIGN ENGR, 31, single, 8 yr experience in design and analyzation of manual and automatic telephone circuits. Experience on relay and switch controlled circuits for signaling or alarms. Available at once. D-1647.

E.E. GRAD., 27, single, desires position in design, development or teaching. One yr testing d-c machinery and controls, 4 yr development of outside plant hardware for telephone use. Available at once. Salary and location open. D-1305.

E.E. GRAD. of Purdue, 18 yr experience in railway, power plant, substations, transmission line, steel mill and paper mill design, construction and operation. G. E. test. Valuation, appraisal, invention. Two yr sales. Available now. Location immaterial. C-8256.

ELEC. DESIGNER, 32, married, equivalent of a college education, best of references, 14 yr experience in design of hydroelectric and steam power plants, automatic railway, high and low tension substations and low tension network systems. Available at once. Location immaterial. B-8628.

Executives

INDUS. CONTROL AND SWITCHGEAR ENGR, Cornell graduate, married. Practical technical experience of 15 yr estimating, design, building, installation and operating of manual and automatic control applied to productive and central station industries. D-1273.

AVAILABLE AT PRESENT e.e. grad. 1920. Twelve yr. Bell System experience, 2 months' G.E. test. Married, 2 children. D-1617.

E.E., grad., 33, single, 9 yr experience. G. E. test and switchboard engg. Is thoroughly familiar with relay, meter and power circuits together with a broad knowledge of power plant and industrial elec. requirements. Can locate anywhere. B-8365-4018-Chicago.

E.E. GRAD., 37, married, with 15 yr experience covering Westinghouse test and public utility operation, finance and valuation. Familiar with elec., gas, and water properties. Prefer executive position with public utility. Location immaterial. D-1639.

ELEC.-MECH. ENGR; univ. grad., married, 34; 4 yr steel mills, one yr G. E. test, 3 yr public utility, 4 yr industrials. Estimates, designs, specifications, developments, tests, construction, supervision. Steam hydraulic power plants, manual automatic substations, converter stations, industrial buildings, overhead underground transmission systems, high low voltage equipment. Available immediately. C-2907.

ASST. ENGR, 14 yr experience, 34, married. Nine yr with 2 large eastern utilities, full engg charge in the installation and maintenance of substations and generating stations. Five yr with leading mfgr., design, development and production engg, outdoor substations and substation and transmission switching and protective equipments. D-1644.

B.S. in E.E., 26, single. Three yr general engg experience, including erecting and testing power equipment; conducting illumination and voltage surveys. Peculiarly fitted for e.e. service in Spanish speaking countries; can speak Spanish and English equally well. D-1462.

GRAD. ENGR, age 31. Ten yr experience in public utility and industrial field. Most of time on standardization, valuation and other problems of public utility economics including future expansion and budgetary control. Am conscientious worker and will make good man for some utility wishing to study changing economic conditions. B-6934.

ELEC. ENGR, married, E.E., M.E. 22 yr experience, designing, construction power plants, substations, transmission, distribution systems, and industrial plants. Three yr charge purchasing engineering equipment, foreign interests. Three yr executive experience charge engineering department large utility syndicate. English, German, Russian, Armenian, Turkish languages. Available immediately. D-84.

GRAD. E.E., B.Sc., Master Bus. Adm., studies toward M.Sc., 36, single; 15 yr broad experience; power plant, substation design and wiring diagrams; appraisals; automatic telephone equipt., cable inspection and specs.; test work on motors and gens.; instructor elec. lab. Desires position of responsibility with industrial concern, utility, consulting engr or teaching. B-7877.

Inspection

ELEC. GRAD., 38, single, 6 yr experience factory testing, W.E. & M. Co., East Pittsburgh, Pa. One yr steel company installing and testing elec. equipment. 6 months' factory inspection of transformers. 2½ yr general inspection of elec. equipment with insurance co. Good reference. Available immediately. Any location. D-1461.

Instruction

GRAD. E.E., 7 yr teaching, 18 yr practical experience. The last 12 yr has been along mechanical lines; steam, gas, air and water engineering, ore and alkali plants, handling, conveying, and process equipment. Taught heat power engineering at Oregon State College and elec. lab. at Beaune, France. Location immaterial. A-3651.

GRAD. E.E., and M.S. in Physics, 30, married. Three yr teaching physics in univ. Five yr research, high voltage insulation studies; ferromagnetic alloys; a-c, d-c, high frequency measurements; high vacuum technique; X-ray analysis. Publications. At present grad. asst. in physics. Desires teaching physics or e.e., engg or research position. Available Jan. 1. D-1616.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St. San Francisco	205 West Wacker Drive Chicago	31 West 39th St. New York

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge, repeated only upon specific request and after one month's interval. Names and records remain on file for three months, renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra three-cent stamp enclosed for forwarding.

ASSOC. OR ASST. PROF. OF E.E., age 34, B.S. in E.E. and M.S. in E.E. degrees. Five yr teaching experience leading tech. school, 3 yr as asst. prof. Four yr in charge of education and training for national technical corp. Any location C-8967.

Junior Engineers

M.S. in E.E. 1932, Univ. of Pa., 23, single, desires position affording e.e. experience. Salary secondary. Go anywhere. Available immediately D-1601.

GRAD. E.E. 1929, M.S. in E.E. 1932; 18 months' test experience at G. E. Co. with all types of elec. machinery, also some research experience. Desires engg opportunity. Salary and location secondary. Available immediately. C-9003.

E.E. GRAD., 1932; Rensselaer P. I., Sigma Xi 22; single. Desires work in any elec. field. Salary and location immaterial. Available at once D-1296.

I.E.E. GRAD., Pratt Institute, 1932, 20, single. Specialized illumination. Completed Westinghouse illumination course. Capable and not afraid of hard work. Excellent references. Desires any kind of work in elec. field. Location immaterial. Available immediately. D-1594.

1932 GRAD. E.E., B.S., from So. Dakota Univ., 22, single and in excellent physical condition Best of character standing and willing to work hard, starting at the bottom and working up. Desires any position that will pay living wage. Location immaterial and available immediately. D 1635-4393-Chicago.

E.E. GRAD., B.S. Carnegie Inst. of Tech. 1932 A.B. in mathematics Oberlin College 1930. Age 24. single, member of Eta Kappa Nu. Location and salary immaterial. Want to gain experience. Available at once. D-1640.

RECENT CORNELL GRAD., 23, single, holding B.S. in E.E. and M.S. deg.; desires connection with opportunity for a future responsible technical position. Excellent scholastic and personal records. A little factory experience. D 1621.

B.S. in E.E. 1931, Mich. Col. of Min. & Tech., single, 23, Tau Beta Pi. Desires work in any engg field. Experience: 3 months' swbd. wiring, 1 month lighting design, 6 months' surveying and map drawing. Speaks Finnish. Location in northern half of U.S. preferred. Available at once. D-1650.

YOUNG ENGR, 23, single. Brooklyn Poly. Inst. evening student, 1927 to date. Five yr varied experience, steam and elec RR construction, secretarial. Well versed in mathematics. Desires position in any engg field. Available immediately; location, New York City. C-8672.

B.S. in E.E. 1927. Married, 28. Five yr experience in telephone work. Desire engg work of any nature or position in law department of mfg. concern. Available immediately. D-1673.

E.E. GRAD., M.I.T., S.B., 1931, S.M. 1932, 24, single. 16 months' experience with Edison Electric Illuminating Co. of Boston as a cooperative student. Desires position in power transmission field, but is interested in any position with a reasonable chance for advancement. Location immaterial. References. D-1685.

GRAD. E.E., 1929, single, 24. Fifteen months' student engr on G. E. test. Some test, drafting and switchboard construction experience before graduation. Interested in position with concern doing consulting or construction work or with utility or mfr. Available at once. Location anywhere in U.S., but New England preferred. C-8028.

B.S. in E.E. recent, 4 yr radio experience. Desires any position, moderate salary. Age, 22 years. D-1488.

B.S. in E.E., 1932, single, 21. Gained experience in elec. instrument plant during cooperative course. Desires any position for experience. Salary secondary. D-1578.

Maintenance and Operation

PRACTICAL ELEC. CONST. AND MAINT. CHIEF, age 32, single, 14 yr experience in construction work, also maintenance and operation of mines and industrial plants. Last 4 yr in Latin America. Can speak Spanish and German well. Available immediately. Location, immaterial. C-2101.

ELEC. GRAD., 15 yr broad experience, factory testing, construction, substation operating and maintenance. Theoretical and practical. Desires position of responsibility. C-38.

Research

RESEARCH: testing and research engr: phys., tests of materials, metallography, X-ray and spectroscopic structure analysis. Well versed in physics. Languages: English, German, French Location and salary of secondary importance to opportunities. C-6994.

M.S. in E.E., Johns Hopkins Univ., Univ. of Pa. fellowship holder, married, good health, analytical, 28. Two yr teaching experience, mathematics, physics, e.e., 2 yr practical, theoretical experience, long-distance telephone transmission from New York to San Francisco. Desires teaching, personnel, research along mathematical-physical lines, or invites correspondence. Excellent references. D 1609.

E.E., 28, married, has $3^1/_2$ yr experience in lab., testing and research work, desires position, preferably with small concern anywhere in U.S. D-1657.

RESEARCH AND DEVMT. ENGR, B.S. and M.S. in E.E. Two yr additional grad. work in physics. Single, 28. Five yr with Westinghouse. Experimental work dealt with arc rupture, control apparatus, and the use of X-rays to study molecular structure. Location and salary secondary to position with opportunity for future. D-1331.

HYDROLOGICAL & METEOROLOGICAL RESEARCH ENGR B.S., M.S. & E.E., 7 yr hydroelec. experience in large public utility engg dept., 3 yr studying climate cycles, ground waters and storage reservoirs, forecasting precipitation runoff and storage, testing flow lines, penstocks and turbines, making stream measurements and snow surveys. Location U.S. or foreign. C-6853.

E.E. GRAD., Penn State, 1932, Honors, 22, single. Some experience in shortwave receivers. Desires research work in short-wave, ultra shortwave, photo electric cells, vacuum tubes, etc., also radio communication at sea. Either foreign or domestic field. Salary secondary. Available now. D-1513.

Sc.D. in E.E. M.I.T. '32; 7 yr Univ. education; 9 yr pract. exp., power, communication and business engg; 2 yr testing course; publications. Extensive knowledge of languages; available. Location immaterial. D-747.

Sales

SALES ENGR, 30, single, E.E. grad. of a reputable one yr engg school. Five yr experience selling industrial and central station instruments. Desires position as salesman with a high grade mfg. concern. No particular line desired. Will travel, location immaterial. C-1570.

Testing

ELEC. INSPECTOR OR TEST MAN, 29, single, 8 yr experience with power and manufacturing companies. Also experience with automatic telephone equipment and communication. Knowledge of theory as well as practise. Can furnish best of references. Location immaterial. Available at once. D-1618.

Membership

Recommended for Transfer

The board of examiners, at its meeting of November 9, 1932, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the acting national secretary.

To Grade of Fellow

Lyon, Waldo V., prof. of elec. machinery, Mass. Inst. of Tech., Cambridge, Mass.
Merwin, Louis T., vice-pres., and gen. mgr., Northwestern Elec. Co., Portland, Ore.
Sabbah, Hassan Camil Ali, elec. engr., Gen. Elec. Co., Schenectady, N. Y.
Sheehan, John E., chief engr., Houston Lighting & Power Co., Houston, Texas.

To Grade of Member

Adler, Wm. M., asst. to distribution engr., Bronx Gas & Elec. Co., Bronx, N. Y.
Beckman, Joseph S., engr. of plant extension, Bell Tel. Co. of Pa., Philadelphia, Pa.
Bricker, L. B., division maintenance supervisor, Southwestern Bell Tel. Co., Houston, Texas.
Bureau, E. A., prof. of elec. engg., Univ. of Kentucky, Lexington, Ky.
Burrows, C. R., radio research engr., Bell Tel. Labs., Inc., Deal, N. J.
Cannon, Robert S., pwr. plant foreman and elec. engr., Lago Petroleum Corp., Venezuela, S. A.
Gould, Leroy B., inductive relations engr., New England Tel. & Tel. Co., Boston, Mass.
Howarth, Oliver, technical engr. and meter supt., Lancashire Elec. Pwr. Co., Manchester Eng.
Johnson, Royce E., director, elec. stds. lab. and instructor in elec. engg., Univ. of Wisconsin, Madison, Wis.
Lidbury, Frank A., pres. and gen. mgr., Oldbury Electro-Chemical Co., Niagara Falls, N. Y.
Mueller, Walter E., patent solicitor, Denison & Thompson, Syracuse, N. Y.
Ortlieb, Otto P., engr. of street lighting, City of Trenton, Trenton, N. J.
Pokorny, Jerome J., elec. engr., Cleveland Elec. Ill. Co., Cleveland, Ohio.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the acting national secretary before Dec. 30, 1932.

Adams, E. F., 839 Monroe Ave., Elizabeth, N. J.
Anderson, I. Jr., 108 Burncoat St., Worcester, Mass.
Barbee, G. C., Southwestern Bell Tel. Co., St. Louis, Mo.
Barnett, H. G., Ore. State Col. Corvallis, Oregon.
Beale, F. S., 1802 Cleveland Blvd., Caldwell Idaho.
Beard, W. G., Rippowam, Ridgefield, Conn.
Beckert, J. E., 27 Clarendon Place, Buffalo, N. Y.
Bell, J. S., Mass. Inst. of Tech., Cambridge, Mass.
Brainard, W. E., 12222 Taft Ave., Cleveland, Ohio.
Briansky, D., 6730 13th Ave., Brooklyn, N. Y.
Brigham, E. R., 1503 Superior St., Toledo, Ohio.
Brown, J. D., Hatfield Wire & Cable Co., Hillside, N. J.
Bruggink, C. P., 309 10th St., Hoboken, N. J.
Burmiester, H., Safe Harbor Water Power Corp., Safe Harbor, Pa.
Calkins, D. S., Henrietta, N. Y.
Carlson, R. W., No. Dak. R. R. Commission, Bismarck, N. D.
Carson, H. E., New England Power Engg & Service Corp., Worcester, Mass.
Colegrove, W. D., Remus, Mich.
Collins, J. E., National District Telegraph Co., New York, N. Y.
Crawford, E. J., Oyama, B. C., Canada.
Deck, H. A., Gen. Elec. X-Ray Corp., Dallas, Texas.
Devine, B. A., City & County of San Francisco, Calif.
Frey, G. O., Warner Bros. Theatres, Inc., New York, N. Y.
Gammons, J. M., Southwestern Bell Tel. Co., St. Louis, Mo.
Gegelys, C., United Electric Lt. & Pwr. Co., New York, N. Y.
Gerlach, W. G., Gen. Elec. Co., Toledo, Ohio.
Gustafson, W. G., Bell Tel. Labs., Inc., New York, N. Y.
Hagood, G. B., Jr., Winnsboro, S. C.
Hanson, J. W. (Member), Columbia Engg. & Mgt. Corp., Cincinnati, Ohio.
Harvey, G. C., Gibbs & Hill, Inc., Rahway, N. J.
Hatfield, L. N., KWSC, State Col. of Wash., Pullman, Wash.
Haward, R., The Saskatchewan Pwr. Commission, Regina, Saskatchewan, Can.
Hawley, E. F., Ormstown, P. Q., Canada.
Heidenreich, E. C., Dental & Medical Elec. Equipment, Buffalo, N. Y.
Hope, H. W., 338 Harvard St., Cambridge, Mass.
Howell, W. J., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Hudgins, W. D., 1422 Arch St., Berkeley, Calif.
Hutchinson, M. C., 316 West 14th St., New York, N. Y.
Johnson, H. W., 31 Washington St., East Orange, N. J.
Johnson, V. T., 3610 Bellevue Ave., Los Angeles, Calif.
Jucciarone, N. T., Otis Elevator Co., Yonkers, N. Y.
Kahlbaum, M. E., Kahlbaum Brothers, Carleton, Mich.
Kastens, R. H. C., 105 Hauxhurst Ave., Weehawken, N. J.
Kelsay, W. D., 401 Martinique St., Dallas, Texas.
Kowalewski, H. M., B. F. Sturtevant Co., Boston, Mass.
Kuhlman, P. W., 509 Smith Ave., Detroit, Mich.
Laine, M. W., 546—40th St., Brooklyn, N. Y.
Libby, C. C., University of Cincinnati, Cinc., Ohio.

Lindsay, V. H., B. F. Sturtevant Co., Hyde Park, Mass.
Lindsley, R. P. Jr., So. Methodist Univ., Dallas, Texas.
Lockie, A. McL., Rensselaer Polytechnic Inst., Troy, N. Y.
Mahalak, A. F., Michigan Alkali Co., Wyandotte, Mich.
Malone, C., Jr., Monongahela West Penn Public Service Co., Fairmont, W. Va.
Martinson, E. O., Box 5, Harrah, Wash.
McCracken, G. I., 1525 Termon Ave., N. S., Pittsburgh, Pa.
McFarlin, V. S., 922 Beacon St., Boston, Mass.
McNarney, H. J., 158 West Maple St., Wabash, Indiana.
Miller, H. W. R., New York Tel. Co., New York, N. Y.
Miller, W. H., 1956 North High St., Columbus, O.
Mitchell, F. H., Mitchell Radioservice Co., Mobile, Ala.
Morgan, J. M., 737 Ridgway Ave., Morgantown, W. Va.
Morton, P. L., Firland, Richmond Highlands, Wash.
Mowat, D., Saskatchewan Power Commission, Regina, Saskatchewan, Can.
Munroe, J. P., 120 Hobart St., Ridgefield Park, N. J.
Osgood, V. L. (Member), Hardwick-Hindle, Inc., Newark, N. J.
Parsons, C. B., 1261 Atlantic St., Portland, Oregon.
Pashek, R. J., 1969—25th St., Detroit, Michigan
Rahlke, H. W., P. O. Box 199, Salem, Ohio.
Ranson, L. R., Gen. Elec. Co., Schenectady, N. Y.
Reizenstein, M., Jr., 2134 Brookfield Ave., Baltimore, Md.
Riedy, K. F. R., Route No. 4, Allentown, Pa.
Roberts, F. F., R. F. D. No. 2, Parma, Idaho.
Rogers, A. G., Clio, Mich.
Roswell, E. R., P. O. Box 203, Devon, Conn.
Scrutchin, C. G., 227 Hancock St., Decatur, Ga.
Sechler, F. E., Great Western Sugar Co., Ovid, Colo.
Senn, J. W., Southern Bell Tel. & Tel. Co., Louisville, Ky.
Stanton, S. W., United Electric Lt. & Pwr. Co., New York, N. Y.
Sterling, O. R., Hop Bottom, Pa.
Stewart, H. M., Humble Oil & Refining Co., Baytown, Texas.
Stieg, H. R., 157 Monroe St., Hartford, Conn.
Tankovich, J. G., 497 East 11th Ave., Columbus, Ohio.
Thomas, R. G., Carolina Pwr. & Lt. Co., Raleigh, N. C.
Walsh, W. C., Rt. No. 2, Box 379, Gilroy, Calif.
Wanner, L. R., Phila. Elec. Co., Philadelphia, Pa.
Wiedenheft, A. H., Good Thunder, Minn.
Willson, W. H., Jr., Randall, Iowa.
Wells, M. F., 261 Hartford Ave., Wethersfield, Conn.
West, C. V., 2001 Barton Ave., Richmond, Va.
Weston, F. B., Sage Allen & Co., Inc., Hartford, Conn.
Womack, S. H. J., Bureau of Standards, Washington, D. C.
Woodruff, R. T., 232 E. Broadway, Girard, Ohio.
Woodward, M. W., Cheyenne Wells, Colorado
Young, C. E., Johns Hopkins Univ., Baltimore, Md.
Zeitz, A., 264 Berriman St., Brooklyn, N. Y.
95 Domestic

Foreign

Lautier, V., 37 Sda. San Paolo, Cospicua, Malta.
Lindorf, L. S., Bol. Kommunisticheskaia 7 Kv. 1 Moscow 4, U.S.S.R.
Lloyd, H. S., Metropolitan-Vickers Elec. Co. Ltd., Traford Park, Manchester, England.
Sarda, P. M., Ratan Pole, Nagori Pole, Ahmedabad, India.
Singh, H., Simla Municipal Committee, Idgah, Simla, India.
Swami, T. V., Elec. Dept., Cocanada, India.
Tharani, J. J., Elec. Pwr. House, Veraval, Kathiawar, Manavadar, India.
7 Foreign

Engineering Literature

Unless otherwise specified, books in this list have been presented by the publishers. The society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

BERECHNUNG von GLEICHSTROM-KRAFTÜBERTRAGUNGEN. By O. Burger. Berlin, Julius Springer, 1932. 82 p., illus., 9x6 in., paper, 6.40 rm.—A practical discussion of the calculation of long-distance a-c transmission lines, in which attention is paid to economic and electrical factors. Various methods of transmission are compared.

COMPANY PLANS FOR UNEMPLOYMENT RESERVES. Washington, D. C., Chamber of Commerce of the U.S., Dept. of Manufacture, 1932. 42 p., tables, 9x6 in., paper, gratis.—To assist employers who desire to devise means for protecting their staffs from unemployment. Purpose and advantages of company reserve plans, coverage and experience of existing plans, procedures for establishing plans, and development of uniform plans by industries or communities, are discussed.

ELECTRIC AND MAGNETIC FIELDS. By S. S. Attwood. N. Y., John Wiley & Sons, 1932. 314 p., illus., 9x6 in., cloth, $3.50.—Represents a course given to students of E.E. at the Univ. of Mich., to coordinate the under-class work in mathematics, mechanics and physics with professional work of the last 2 years. The book is in 4 parts: electric field; magnetic field; ferromagnetic field; and combined electric and magnetic fields.

ELECTRONS AND WAVES. By H. S. Allen. Lond. & N. Y., Macmillan Co., 1932. 336 p., illus., 8x5 in., cloth, $2.50. Consists of lectures dealing with recent progress in our knowledge of the constitution of matter and the nature of radiation. Intended for readers who have not specialized in physics, but who wish something more than an entirely elementary account of the subject. Such topics as relativity, the quantum theory, radioactivity and wave mechanics are presented in this concise outline.

ELEKTRISCHE GASENTLADUNGEN. Bd. 1. By A. v. Engel and M. Steenbeck. Berlin, J. Springer, 1932. 248 p., illus., 10x6 in., cloth, 25.50 rm.—This treatise, which will comprise 2 volumes, aims to provide a systematic, comprehensive discussion of the discharge of electricity through gases, in which the needs of the experimenting physicist and the research engineer will be given consideration above those of the student of atomic physics. This volume develops the basic laws of discharges in gases from simple concepts, without using difficult mathematical processes and compares them with experimental results.

HANDBOOK of CHEMISTRY and PHYSICS. Edit. by C. D. Hodgman. 17 ed. Cleveland, Ohio, Chemical Rubber Pub. Co., 1932. 1,722 p., tables, 7x5 in., leather, $6.00.—This edition has undergone an extensive revision which has resulted in an addition of 150 pages of new matter. 1,000 new compounds have been added to the table of physical constants of organic compounds, which now includes over 4,000 substances, and the former data carefully corrected. The mathematical section has been enlarged by adding several useful tables; new tables have been added to all divisions of the book.

HANDBOOK of INDUSTRIAL TEMPERATURE and HUMIDITY MEASUREMENT and CONTROL. (Manual of Instrumentation.) Parts 2 and 3.—By M. F. Béhar. Ed. 1. Pittsburgh, Instruments Pub. Co., 1932. 309 p., illus., 10x6 in., cloth, $4.00.—Having presented the fundamentals of industrial instrumentation in his first volume, Mr. Béhar now takes up 2 subjects, the measurement and control of temperature and of humidity. Detailed information is presented upon thermometers, pyrometers, heat recorders and controllers, and instruments for measuring and controlling humidity. Detailed descriptions of the principal instruments on the market, and general principles underlying them are presented.

Die KÜNSTLICHEN KOHLEN für elektrische Öfen, Elektrolyse und Elektrotechnik. By K. Arndt. 2 Auflage. Berlin, J. Springer, 1932. 336 p., illus., 9x6 in., leather, 38 rm.—A comprehensive account of the carbon electrode industry. After a short historical introduction, raw materials are considered, their mixing, ignition and preparation described. Chapters then follow upon chemical, physical, and microscopic testing and upon the use of carbon electrodes in furnaces and baths. Carbons for arc lamps, brushes, batteries, microphones, and other purposes are discussed. The book is a rewritten edition of Zellner's work on this subject.

REFRIGERATION, including Air Conditioning and Cooling and Household Automatic Refrigerating Machines. By J. A. Moyer and R. U. Fittz. 2 ed. New York and London, McGraw-Hill, 1932. 538 p., illus., 9x6 in., $5.00. Intended both as a textbook and reference work as a useful outline of current conditions and practise. The theory of refrigeration and the methods in use are described and explained. New features of improved designs of household and small commercial refrigerators, silica-gel systems, revised data on refrigerants, production of dry ice, applications of quick freezing, and air conditioning, are described.

REWINDING SMALL MOTORS. By D. H Braymer and A. C. Roe. 2 ed. New York & London, McGraw-Hill, 1932. 263 p., illus., 9x6 in., cloth, $2.50. Intended as a guide to repairmen called upon to rewind portable drills, motors for automobile starters, sewing machines, vacuum cleaners, fans and other small machinery. A chapter on single-phase motors of the condenser type has been added. The directions are full and detailed and sufficient for all needs of experienced winders.

STEAM POWER PLANT ENGINEERING. By L. A. Harding. New York, John Wiley & Sons, 1932. 777 p., illus., 9x7 in., cloth, $10.00. To outline briefly in an elementary manner the major problems in the design of steam generators, engines, turbines and accessories, to show their interrelations in power plant engineering, and to discuss the economic factors involved in their selection. A large amount of practical data not readily accessible elsewhere is assembled in convenient form, making it useful for reference as well as for study.

TABLES OF CUBIC CRYSTAL STRUCTURE OF ELEMENTS AND COMPOUNDS. By I. E. Knaggs, B. Karlik and C. F. Elam. London, Adam Hilger, Ltd., 1932. 90 p., tables, 10x6 in., cloth, 11s. 6d. A useful reference book for chemists and metallurgists who use X-ray methods for the analysis of powders and crystals. One section upon inorganic and organic substances; and another upon alloys. Each section gives table listing the substances: alphabetically, and systematically by the side length of the unit cube cell. The bibliographies contain over 900 references. An attempt to tabulate all data scattered through periodicals up to August 1931.

THERMODYNAMICS. By J. E. Emswiler. New York & London, McGraw Hill, 1932. 347 p., 9x6 in., cloth, $3.00. The special feature of this textbook is a progression from the topics most familiar to the student to those with which he is inexperienced. Study of the steam engine comes first, followed by vapor refrigeration, permanent gas mixtures and air heat engines; finally the laws of thermodynamics and the kinetic theory of heat. Earlier edition partly rewritten and new matter added.

URBAN LAND USES, Amounts of Land Used and Needed for Various Purposes by Typical American Cities, an Aid to Scientific Zoning Practice. (Harvard City Planning Studies, v. 4.) By H. Bartholomew. Cambridge, Harvard Univ. Press, 1932. 174 p., 10x7 in., cloth, $3.50. The results of an investigation undertaken to determine the requirements of the American city as to the land areas used for various purposes, the ratios of these areas to a given population unit, and analogous statistical information of aid in scientific zoning. These data provide a method for estimating the total area required for each particular urban use for any given future population of between 5,000 and 300,000 inhabitants.

WORLD SOCIAL ECONOMIC PLANNING, the Necessity for Planned Adjustment of Productive Capacity and Standards of Living. 2 v. The Hague, Holland, Intl. Industrial Relations Inst.. also Room 600, 130 East 22nd St., New York, 1932. 935 p., 10x6 in., cloth, $2.50. Containing papers and discussions presented at the Congress in Amsterdam in 1931, when the necessity for planned adjustment of productive capacity and standards of living was discussed by a group of economists and sociologists of many countries.

Industrial Notes

General Electric to Exhibit at Chicago Fair.—The "House of Magic," a spectacular section of the G-E research laboratories, will be moved to Chicago for the 1933 World's Fair as the outstanding feature of the General Electric Company's exhibit. The exhibit will occupy 9,000 sq ft of space in the circular hall of the Electrical Building and will represent an investment of five hundred thousand dollars.

Roller-Smith Appointments.—Mark G. Mueller, 1700–16th St., Denver, has been appointed by The Roller-Smith Co., New York, as district sales agent for the states of Colorado, New Mexico, and the western part of Kansas. Burkholder and Kelley, 105 Cortleigh Boulevard, Toronto, have been appointed representatives for the Dominion of Canada.

Rockbestos Moves Chicago Office.—The Rockbestos Products Corp., New Haven, Conn., manufacturers of asbestos insulated wires and cables and flexible cords, announces a change in the location of its Chicago office and warehouse from the Madison Terminal Building to the Marquette Building, 140 So. Dearborn St., Chicago, Ill.

L. M. Christie Promoted by National Fireproofing Corporation.—L. M. Christie has been elected vice-president of the National Fireproofing Corporation, Pittsburgh, with which he has been connected since 1902. He will continue in charge of the sales engineering end of the conduit division. Mr. Christie has been identified with the clay conduit branch of the electrical industry almost from its inception, coming to the states from Windsor, Canada, in 1900 to enter the employ of John T. McRoy. The latter was an inventor and a pioneer manufacturer of the present type of multiple duct clay conduit for housing telephone, telegraph, and electric power cable lines.

Calculating Board in Regular Use by Utility.—Studies of power flow, regulation, losses, power factor and system stability are made quickly and easily on the alternating-current calculating board recently installed in the engineering department of the Commonwealth Edison Company, Chicago. Built by the Westinghouse Electric & Manufacturing Company, it is said to be the first alternating-current calculating board to be placed in regular use by an operating utility. It operates on a frequency of 440 cycles. On it can be reproduced in terms of circuit constants the whole or any part of the Commonwealth Edison a-c system.

General Electric Receives Largest Mercury Shipment.—What is probably the largest single shipment of mercury ever made arrived in New York recently for the General Electric Company, to be used in generating power in the new 20,000-kilowatt mercury turbine just installed at the Kearny station of the Public Service Corporation of New Jersey. The shipment consisted of 270,000 pounds, and was delivered in 3553 iron flasks, each flask containing 76 pounds. The value of the mercury in the whole order is about $356,000, as this shipment represents only half of the company's needs. The remaining 270,000 pounds will be delivered later and will be used for generating power in the new mercury turbine plant being built in Schenectady. The total order represents about 89 per cent of the mercury consumed by the United States in an average year.

Bristol Opens British Factory.—The Bristol Co., Waterbury, Conn., announces the establishment of a British factory at London under the name of Bristol's Instrument Co., Ltd. Since 1889 the Bristol Company has had a very substantial trade with Great Britain in its line of recording instruments, its selling activities in that country being handled by J. W. & C. J. Phillips, Ltd., as sales agent. Although the general expansion program of the company contemplated the founding of a British plant at some future time, the altered economic and business situation within Great Britain made an earlier establishment for manufacturing in that country seem advisable. Howard H. Bristol, president of The Bristol Company, recently made a special trip to London to investigate the situation, and during his visit laid the plans and arranged for the formation of the British company. The new plant, located at 144 Pomeroy St., New Cross, London, consists of an office building and a two-story factory building of modern construction, and is prepared to manufacture and service the complete line of the company's indicating, recording and controlling instruments.

A New Testing Device.—Ferranti, Inc., New York, has introduced a complete testing kit comprised of the dual range clip-on ammeter, which met with widespread acceptance a few months ago, and a three range portable voltmeter. The clip-on ammeter has two scales, 0/100 and 0/500 amperes, and reads accurately currents ranging from 10 to 500 amperes without the necessity of breaking the circuit or the use of split-core current transformers. The instrument is simply clipped over the conductor and the current is read off directly. It can be operated with one hand, and is suitable for use either on the ground or up a pole. The second instrument in the set, the triple range portable voltmeter, has full scales of 150, 300, and 600 volts which take care of the standard distribution voltages of 110, 220, 440, and 550. This meter, although of the moving iron type, has a comparatively high resistance, making its readings extremely accurate. It is suitable for use on either direct or alternating current and is independent of frequency between 25 and 100 cycles.

The two instruments in this set are accurate and convenient, and although of a precision nature, they are robust in construction. They are supplied in a solid leather case equipped with lock and key, in addition to hand and shoulder carrying straps. The set is particularly adapted for determining the actual voltage and loading on transformers, motors, etc., for balancing secondary transformer loads on three-wire services, or for checking power consumers' loads and voltages. It may also be used to check single or three-phase kva.

Trade Literature

Arc Welders.—Bulletin HW-2, 20 pp. Describes the improved line of P & H Hansen arc welders, designed by K. L. Hansen. Harnischfeger Corp., Milwaukee.

Condensers.—Catalog, 16 pp. Included in this complete line are a series of oil impregnated, oil filled paper condensers especially adapted for use with capacitor motors, power factor correction and other industrial applications. Electrolytic, paper and mica condensers are also described. Dubilier Condenser Corp., 4377 Bronx Blvd., New York.

Wire Rope Slings.—Catalog, 86 pp. Includes the latest available information on various types of slings now being used in shop and field for the handling of all kinds of loads. Numerous illustrations show the application of these slings in handling heavy apparatus and castings. John A. Roebling's Sons Co., Trenton, N. J.

Square Case Instruments.—Bulletin L 20545, 8 pp. Describes a new line of switchboard square-case instruments, including ammeters, milliameters, voltmeters, milli-voltmeters, single and polyphase power factor meters, frequency meters, and synchroscopes. Both a-c and d-c instruments are intended for service on large switchboards of steel, ebony asbestos, or slate. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Zinc for Die Castings.—Bulletin 20 pp. Illustrates a multiplicity of uses for zinc die castings. Charts and table on the effect of aging treatments on tensile strength, impact strength, and dimensions of the "Zamak" alloys are published for the first time. Heat treatment for stabilizing the dimensions and properties of a zinc die casting alloy is also discussed. New Jersey Zinc Co., 160 Front St., New York.

Metal-Clad Switchgear.—Bulletin GEA 1661, 12 pp. Describes type MI-6, latest G-E metal-clad switchgear, for a wide range of applications—central station main and auxiliary circuits, industrial plants, etc. The principal improvement of many, in this apparatus, is the use of oil-blast circuit breakers having interrupting ratings from 50,000 to 500,000 kva, 15,000 volts and up to 2,000 amperes. Each unit consists of a complete self-contained switching equipment with a stationary and removable element. General Electric Co., Schenectady, N. Y.


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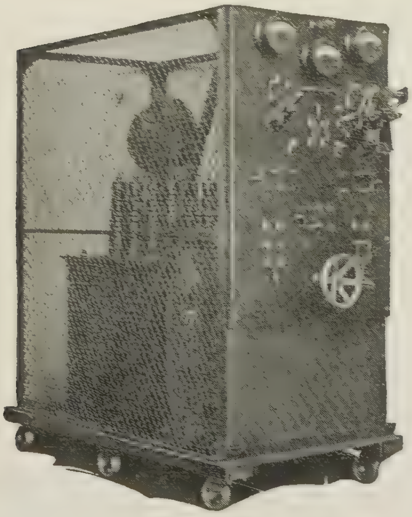

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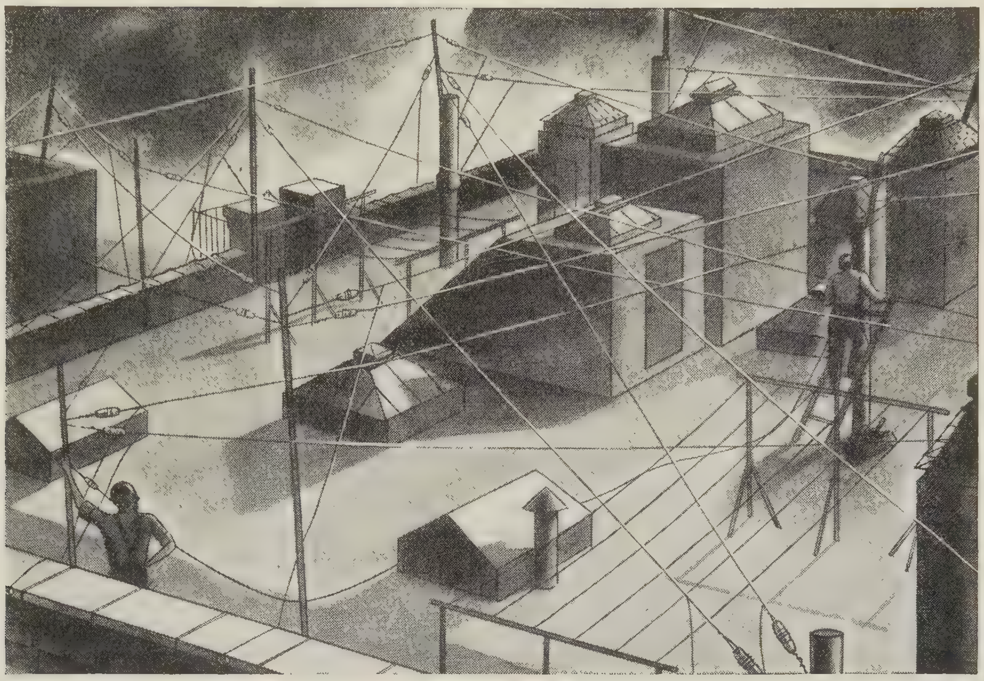

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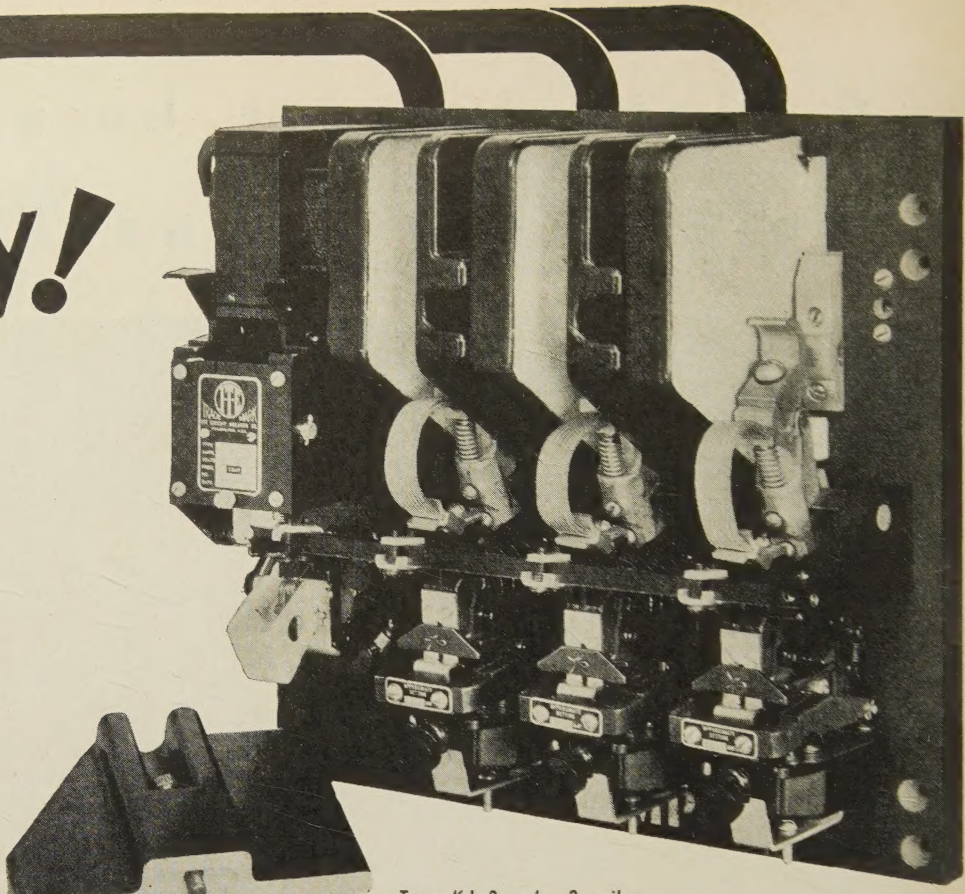

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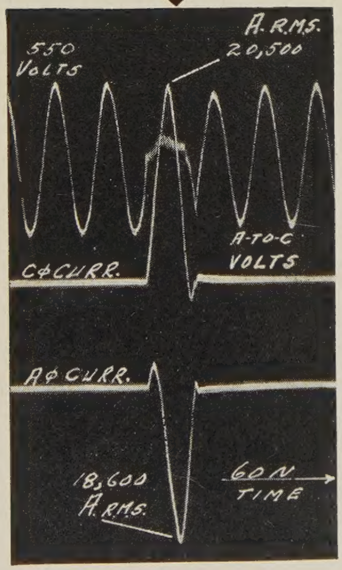

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